HSC/XR-BR-1994-0001

HUMAN SYSTEMS CENTER
PRODUCTS AND PROGRESS

"THERE ARE NO UNMANNED SYSTEMS"

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The HSC Products and Progress brochure was published to present a cross section of HSC's human-centered technologies. These technologies will help keep america militarily and economically strong as we restructure our armed forces to meet unparalleled rapid changes in world military and economic environments. I encourage you to inquire about any HSC technologies which might have the potential to enhance unit's mission performance.

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HUMAN SYSTEMS CENTER PRODUCTS AND PROGRESS

"There Are No Unmanned Systems"

Issued by
HQ Human Systems Center (AFMC)
2510 Kennedy Circle, Suite 1, Brooks AFB, Texas 78235-5120

Designed and Produced by Melissa M. Tarleton
HQ HSC Planning, Requirements, and Engineering
Marketing Office
October 1993

Contents

Vision, Missions, Goals, and Guiding Principle

AIR FORCE VISION: *Air Force people building the world's most respected Air and Space Force ... Global Power and Reach for America.*

AIR FORCE MISSION: *To defend the United States through the control and exploitation of air and space.*

AFMC MISSION: *Through integrated management of research, development, test, acquisition, deliverance, and support, we advance and use technology to acquire and sustain superior systems in partnership with our customers. We perform continuous product and process improvement throughout the life cycle. As an integral part of the USAF Warfighting Team, we contribute to affordable combat superiority, readiness, and sustainability.* ***AFMC goals are:***

GOAL 1: SATISFY OUR CUSTOMERS' NEEDS--IN WAR AND PEACE

GOAL 2: ENABLE OUR PEOPLE TO EXCEL

GOAL 3: SUSTAIN TECHNOLOGICAL SUPERIORITY

GOAL 4: ENHANCE THE EXCELLENCE OF OUR BUSINESS PRACTICES

GOAL 5: OPERATE QUALITY INSTALLATIONS

HUMAN SYSTEMS CENTER GUIDING PRINCIPLE: *To make the human the heart of aerospace systems and operations.*

Quality Air Force: A leadership commitment and operating style that inspires trust, teamwork, and continuous improvement everywhere in the Air Force.

Commander's Assessment

Our bottom line concern at the Human Systems Center (HSC) is: **How well do we meet your human systems needs?**

In a very real sense, HSC's customers are virtually every man and woman in the USAF, and increasingly those throughout the Department of Defense. Now more than ever, with President Clinton's Defense Conversion initiatives and our technology transfer programs, HSC customers also include nondefense commercial industry.

Military or commercial, HSC products have one common denominator: they enable people to do their jobs ... better. While people have not changed biologically over the years, human-centered technologies have dramatically increased their ability to perform. This concept is clearly illustrated in athletics where world records seldom stand for more than a few years. Likewise, HSC's equipment, training products, and operational techniques make today's warfighters and support personnel far more capable than those of just a few years ago.

I invite you to tell us how we are doing. Use any of HSC's various feedback programs, the survey on the following page, or any method you choose to tell us how we can better satisfy your human-centered research and product needs. Our people solicit your inputs and are empowered to respond with programs, procedures, or other changes to improve HSC's product quality.

This brochure presents a cross section of HSC's human-centered technologies. These technologies will help keep America militarily and economically strong as we restructure our armed forces to meet unparalleled rapid changes in world military and economic environments. I encourage you to inquire about any HSC technologies which might have the potential to enhance your unit's mission performance. From your first inquiry for information, through HSC product delivery and support, our number one goal is to **meet your needs.**

George K Anderson

Major General George K. Anderson, USAF, MC
Commander, Human Systems Center

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- learn more about HSC technologies and how they can serve you;

and/or

- tell us how this publication meets your needs and how we can improve it.

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1. Send me additional information about the following HSC technology area.
   (attach additional sheet if required)

2. How can HSC better serve your needs?
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3. Other comments!
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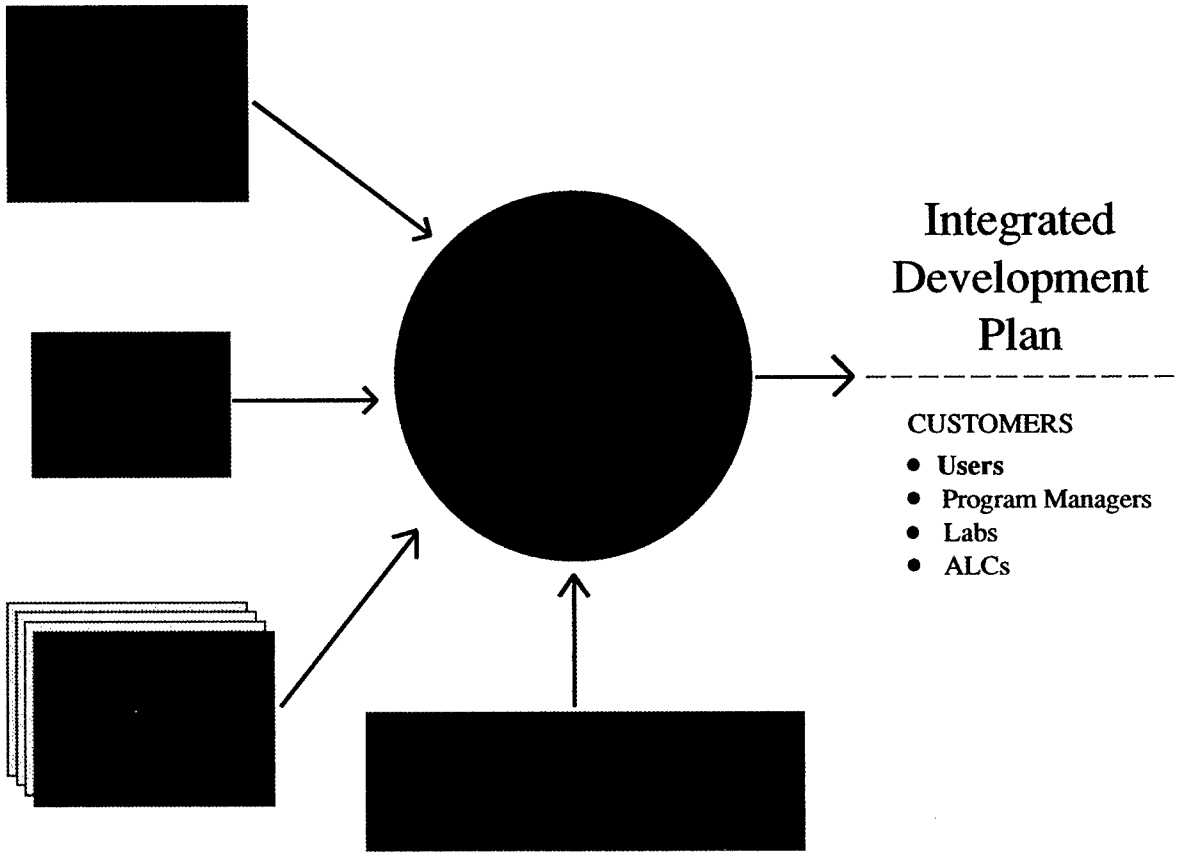
Thank you! Please make a copy of this page and mail to: **HSC Commander, 2510 Kennedy Circle, Suite 1, Brooks AFB TX 78235-5120.** Alternatively, call **HSC Marketing, or a member of the Technical Planning Integrated Product Teams, at DSN 240-4460 or (210) 536-4460.**

Technical Planning Integrated Product Teams

A Technical Planning Integrated Product Team (TPIPT) is a network of key players from operational and support commands who use an integrated product team approach to plan and facilitate superior solutions to the users' operational needs. Human Systems Center has two TPIPTs--Human Systems Integration (HSI), and Environment, Safety, Occupational Health (ESOH)--whose job is to provide solution alternatives for our customers' human-system issues, needs, and requirements.



The TPIPTs, located in HSC/XRT, provide a convenient point of contact for all research, development, and acquisition activities at HSC ... call us today at: (210) 536-4460 [DSN 240].

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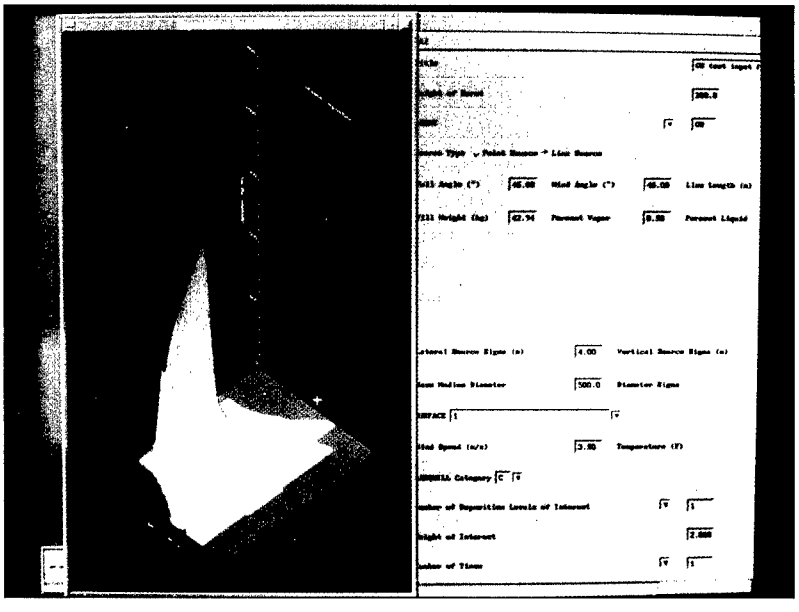
Crew Systems

This Human Systems Center product area accomplishes research and develops, fields, and supports technology and systems to optimize human combat performance and survivability to ensure weapons systems configurations are compatible with human operator requirements.

Nuclear-Biological-Chemical Operability Assessment

Although the traditional chemical and biological warfare threat posed by the former Soviet Union has diminished with the Union's breakup, vulnerability to attack by Chemical Biological Warfare (CBW) has increased. The proliferation of CBW agents is well known and documented. Two major factors behind this explosive rate of spread are opportunity and cost. The opportunity to acquire or develop CBW agents has probably never been higher. The technology is well established and the skills needed are the same ones required for commercial pesticide production or operations requiring fermentation. Equipment for production is readily available and supplied on the open market. Compared to the cost for similar capability offered by nuclear or conventional forces, the price tag for these weapons is quite low.



Computer simulation predicts contamination levels over battlefield area.

Nuclear-Biological-Chemical (NBC) Operability Assessment begins with developing a scenario unique to the study objective. In coordination with the intelligence community, threat assets, including agents and delivery systems, are identified and modeled for selected regions of the globe. Potential US and allied target assets are described and the appropriate meteorological and terrain data gathered. A "red team" composed of threat analysts, operational experts, and simulation specialists is formed, along with a reasonable CBW attack scenario. Simulation models are selected and computer simulations conducted. Output from the simulations include agent challenge levels, contamination areas and persistence, casualty estimates, and predicted operational degradation. Analyses such as these are used to determine technology requirements and procedures for NBC defense, design standards, and realistic planning and training environmental projections.

Some recent products are: (1) "Post" Soviet Union CBW challenge-level assessments for NATO air bases; (2) analysis of the vulnerability of Naval surface assets to CBW attack; (3) definition of worst case, but reasonable challenge levels, for ground crew ensemble design specification; (4) assessment of US forces' vulnerability to CBW in Southwest Asia (after Desert Storm); and (5) publication of updated chemical warfare toxicity standards. Current efforts include: (1) analyzing CBW threat after agent filled warheads have been intercepted by ground based air defense; (2) modifying high altitude chemical and biological dissemination models; (3) developing revised biological toxicity standards; and (4) defining baseline biological warfare equipment capabilities and improvement areas, and developing initiatives to improve capability. Finally, active participation continues in the form of NATO sponsored working groups of experts, international task forces, and ad hoc committees, to identify the CBW challenge environment across a broad spectrum of scenarios.

OPR: AL/CFHA, (513) 255-8869 [DSN 785]

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Chemical Defense Aircrew Ensemble

The current chemical defense ensemble encumbers the crewmember so much that normal tasks are difficult and fatiguing. Continuous protection must be provided during transit from a collective shelter to the aircraft, during flight operations, and then back to the collective shelter. To meet this need, a new Chemical Defense Aircrew Ensemble, referred to as the CWU-66/P, was developed.

F-16 pilot wearing both the CWU-66/P Aircrew Ensemble and a separate respiratory protection mask.

Of two candidate materials considered during development test and evaluation, one fabric using carbon sphere technology proved to be more effective in repelling (and insulating against) chemical agents. This option, however, suffered from problems with comfort and stiffness. The only acceptable option involved further development of an effective material with acceptable physical characteristics. This new fabric, 80 percent Nomex and 20 percent softer fiber, successfully completed initial operational test and evaluation in September 1989. Aircrews stationed at 12 USAF bases participated in this evaluation. Fielding of this item was expedited in response to Operation Desert Shield/Storm. Over 24,000 ensembles have been fielded to date. Follow-on procurement of approximately 40,000 additional units is ongoing

The new one-piece chemical defense ensemble replaces the current aircrew chemical defense ensemble (Nomex flight suit, charcoal undercoverall, and long cotton underwear). It is compatible with the crew station, environment control, and ejection systems of all fixed wing aircraft. It is washable, cooler, lighter weight, nonflammable, and vapor agent protective. With the new chemical defense ensemble, aircrew members can effectively operate their weapon systems confident that they are protected from chemical agents.

OPR: HSC/YAC, (210) 536-2675 [DSN 240]

Chemical Defense Ground Crew Ensemble

The new Chemical Defense Ground Crew Ensemble (GCE) program will produce and field a garment which maintains a high level of chemical protection while greatly improving the ability of wearers to perform their duties in a chemical environment. The GCE program will also develop a decontamination process which extends the combat utility of the new ensemble. The current garment, which protects ground crewmembers against the effects of chemical warfare agents, was originally developed by the Army. This protection, however, has come at the expense of comfort, resistance to heat stress, and durability of the material.

The Human Systems Program Office (HSC/YA) worked closely with the Sustained Operations Branch of the Crew Systems Directorate of Armstrong Laboratory (AL/CFTO), to investigate potential technologies which could be used in the acquisition of the GCE. Human subject testing by AL/CFTO indicates that certain approaches for the new garment can provide chemical protection without increasing heat stress more than 20 percent beyond that currently caused by the standard issue battle dress uniform. Additional testing funded by HSC/YAC indicates that the new suit will be launderable and may even be capable of being safely reused after chemical agent exposure.

OPR: HSC/YAC, (210) 536-2675 [DSN 240]

Even when life threatening chemicals are present, the ground crew will be able to perform their mission with minimal discomfort.

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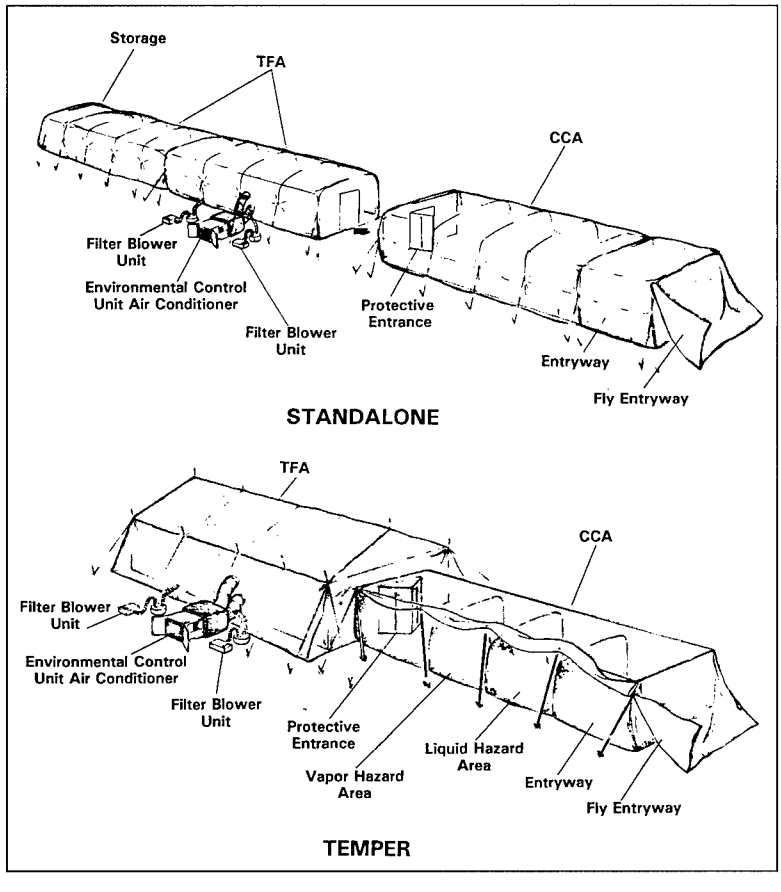
Transportable Collective Protection System

An operational need exists to provide the USAF with a chemical warfare (CW) collective protection capability. This capability is necessary to improve the USAF's ability to operate and sustain operations in a CW environment. In general, collective protection must provide a clean "shirt-sleeve" environment in which personnel can eat, drink, sleep, and perform duties which cannot be adequately performed while wearing individual protective equipment.

The Transportable Collective Protection System (TCPS) provides CW agent protection for mobility forces deploying to "bare bases." It can be transported by USAF cargo aircraft or by ship. The TCPS consists of a Contamination Control Area (CCA) and a host shelter modified for chemical protection using agent proof material and overpressure. Personnel process through the CCA, remove their chemical ensembles, and enter the bare base shelter to eat, sleep, or perform light work. The TCPS is available in three configurations: the tent, extendable, modular personnel (TEMPER) TCPS; the expandable shelter/container (ES/C) TCPS; or the stand-alone configuration in which two CCA units are combined to form the host shelter and a third CCA is used for processing.

United States Air Forces Europe is scheduled to become the first operational unit with the TCPS. Air Mobility Command, Air Force Special Operations Command, and Air Combat Command are also scheduled to receive TCPS units through FY97.

OPR: HSC/YAC, (210) 536-2675 [DSN 240]



A chemical liner is being installed in the "TEMPER" configuration of the TCPS tent during operational evaluation.

Wartime Medical Planning System

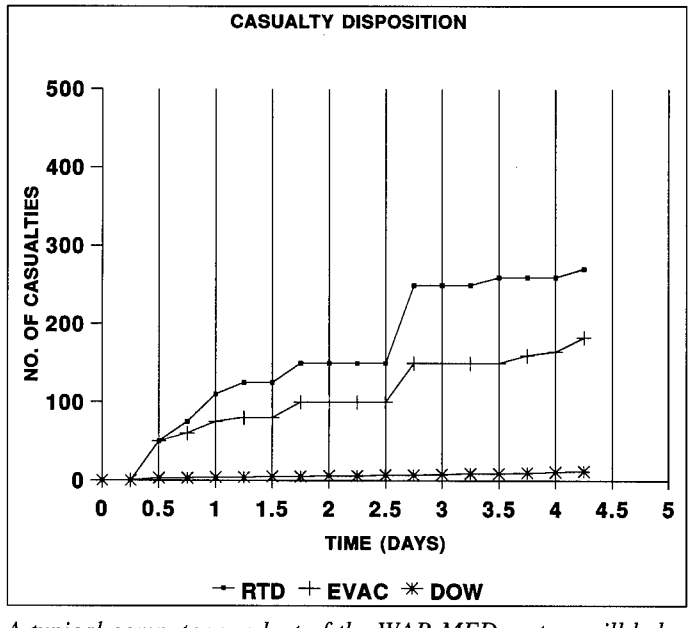
The mission of the USAF Medical Service is to rapidly expand, mobilize, and deploy medical support for USAF contingency operations. Varying threats and operational conditions worldwide make it extremely difficult to assess current capabilities and future requirements. USAF medical planners must have auditable databases and modeling tools for developing and assessing medical plans and support requirements if they are to optimize wartime medical assets for every site, within each theater of operations. The Wartime Medical (WAR-MED) Planning system has been identified as the Surgeon General's top priority development project.

The WAR-MED planning system is being developed to allow for the iterative analysis of integrated wartime medical systems. Straightforward data and graphical outputs will help the medical service to determine wartime manpower and resource allocations and to accomplish analyses of complex wartime medical plans and operations. Computer simulation and evaluation of service unique concepts of medical care, determining the impact of system or treatment changes, assessing the medical service's ability to return personnel to duty or to determine morbidity or mortality outcomes, based on assets employed, will be possible for the first time. This "tool" will assist in deliberate and crisis planning and in establishing realistic training requirements based on identifiable wartime tasks.

During the past year, the first and second echelon prototypes have been evaluated by the Human Systems Center, the USAF Surgeon General's Medical Readiness Division, and the USAF Medical Manpower Engineering Team. A third and fourth echelon model has reached the design phase of development and a concept phase for determining theater model characteristics is well underway.

The WAR-MED system will provide the USAF Surgeon General with the first auditable tool to assess the USAF wartime medical system, based on operationally significant measures of effectiveness. Planning system outputs are based on realistic scenarios and threats derived from the THreat RElated ATtrition (THREAT) System. This design concept allows for reconfiguration and avoids system obsolescence as the medical mission evolves to meet today's and tomorrow's challenges. It will have a significant impact on USAF medical deliberate and crisis planning.

OPR: HSC/YAM, (210) 536-2855 [DSN 240]



A typical computer product of the WAR-MED system will help the Surgeon General plan for wartime casualties.

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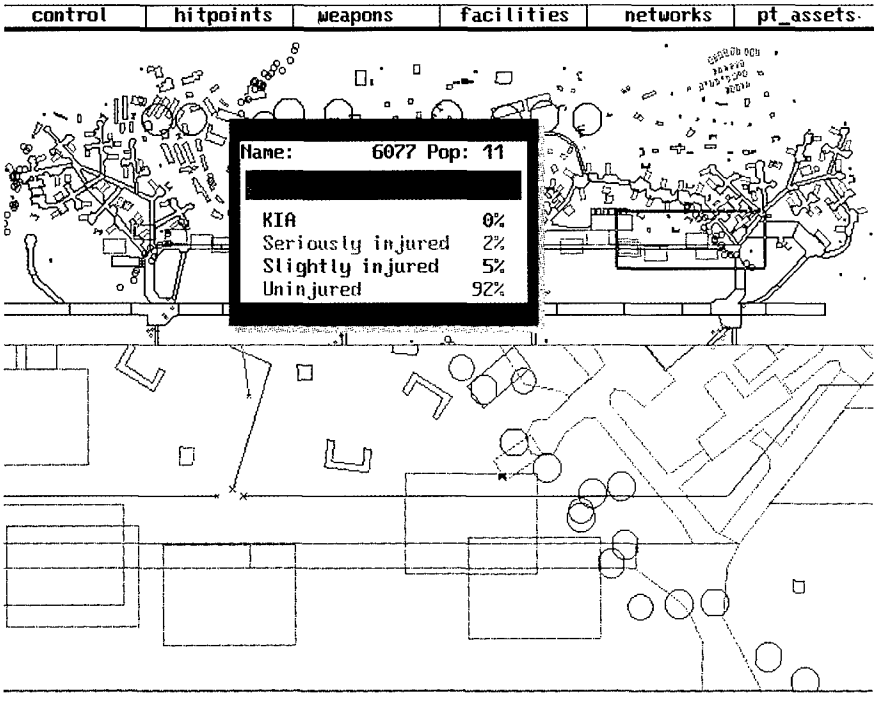
Threat Related Attrition System

The success or failure of a military operation depends on the ability to deploy and maintain sufficient combat force. Understanding the causes and circumstances which result in losing deployed military personnel will allow accurate planning of personnel and logistical requirements, and can lead to strategies for prevention and mitigation. The limitations to such predictions are insufficient information concerning attrition factors and a lack of credible modeling tools to utilize this information. Other DOD agencies have decision-support models; however, these are not satisfactory as they are constructed to support service-specific concepts of operations or are based on notional weapons' effects and human tolerance algorithms. The THreat RElated ATtrition (THREAT) system seeks to produce this information relative to USAF needs in providing methodologies for its analysis and software for its application.

Full-scale weapons' effects studies have been conducted with general purpose bombs, fuel air explosives, tactical air-to-surface missiles, and precision guided munitions. The results of these studies have been incorporated into three models: unprotected, temporary, and permanent facilities. A prototype theater-level model was completed and exercised to produce attrition rates for the Korean theater. The Disease and Non-Battle Injury module was also completed and is now undergoing test and evaluation. During Operation Desert Shield/Storm, the THREAT system was used to conduct a special study for HQ USAF/XO to assess potential noncombatant casualties resulting from the air campaign.

The THREAT system will directly support USAF manpower, personnel, medical, operational, and logistical planners with deliberate and crisis planning. THREAT estimations, based on actual scenarios and human tolerance to weapons' effects, will provide an unprecedented reality to these plans.



THREAT Installation-level graphical output.

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[DSN 240]

Disposable Eye/Respiratory Protection Program

The need for sustained operations in a chemical weapon environment led to a requirement for the Disposable Eye/Respiratory Protection (DERP) program. The DERP will consist of a hood with a filter to cleanse contaminated air, providing the wearer two hours protection against liquid, vapor, and aerosol agents. It will be sufficiently compact that it may fit into the pocket of the ground crew ensemble, the flight suit, and the anti-G suit. The DERP will be a low cost item; the goal is $15 per unit, allowing the mask to be disposed of after each use.

The DERP will be used in a contaminated environment and in a chemically protective shelter when the shelter filtration fails or when emergency evacuation of the shelter is required. In addition, other needs may exist for the emergency mask; these might include supporting aircrews deploying to high threat areas or supporting medical care providers and patients in certain instances.

Protection provided by the DERP mask will support the USAF's mission when personnel are unable to access their standard chemically protective mask/respirator. The payoff will be inexpensive protection for personnel, reducing casualties, and enabling the USAF to maintain a high sortie generation rate under adverse conditions. The ongoing development program will support the award of a production contract in 1995.

OPR: HSC/YAC,
(210) 536-2675
[DSN 240]

Three prototypes are currently being considered.

Aircrew Eye/Respiratory Protection System

The Aircrew Eye/Respiratory Protection (AERP) provides for an improved chemical defense capability for aircrew members. The AERP, referred to as the MBU-19/P, was developed to meet Air Combat Command, Air Mobility Command, and Air Force Special Operations Command requirements. This under-the-helmet system enshrouds a standard MBU-12/P oxygen mask with impermeable material. In addition to the mask/hood portion, the AERP system has a communications system and a blower unit. Upgrades of this system include Valsalva and drinking capabilities plus both tear-away and automated antidrown features for parachute landings in water. Aircrew responses to the AERP system have been positive.

Initial production of the AERP system was initiated in August 1990, followed by full rate production supporting Operation Desert Shield/ Storm. Initial production deliveries started in January 1991 with over 10,000 currently in the USAF inventory. Flight testing in all USAF aircraft, with the exception of development test and evaluation, and operational test and evaluation in the B-1, has been completed. Aircraft modifications to support AERP system integration are in progress at the Ogden, Warner-Robins, and Oklahoma City Air Logistics Centers.

Follow-on production will continue through the year 2001. AERP will ensure crewmembers are protected from chemical agents while maintaining the comfort, mobility, and function necessary to fly all DOD aircraft.

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(210) 536-2675 [DSN 240] and
(210) 925-3756 [DSN 945]

An F-16 pilot prepares for a mission while wearing Aircrew Eye/Respiratory Protection.

Personal Transatmospheric Protection System

As the USAF focuses its mission on projecting global reach--global power, HSC has started to include programs to support manned spaceflight in transatmospheric vehicles. The current high altitude platform, the U-2, utilizes a backup, unpressurized suit which inflates in the event of cabin depressurization. The suit, which is donned prior to flight, is extremely bulky. The crewmember has limited mobility and dexterity while wearing the suit, even when it is unpressurized, and the suit's inadequate ventilation leads to heat stress. These crews conduct long duration flights which, when combined with the suit's shortcomings, result in extreme fatigue and degraded performance.

The Personal Transatmospheric Protective System (PTAPS) program, started in FY92, is a critical experiment for developing and demonstrating improved technology to be incorporated into a full pressure suit. This technology will be used in 21st Century high altitude and transatmospheric vehicles. The approach is to evaluate existing and near-term technology against mission requirements of the U-2 and National AeroSpace Plane (NASP)/NASP Derived Vehicles to determine all the deficiencies in the current suit.

Currently, work is being done on improved gloves and increased mobility joints. The goal is to create a more comfortable and usable suit, whether pressurized or not. The new gloves will offer improved tactility and will be designed to allow the crew to manipulate equipment more easily. The suit will also allow the crew to breathe oxygen en route, rather than prebreathe on the ground. This will reduce crew fatigue and the chance of decompression sickness. Future focus will include an improved helmet, better integration with altitude protection, and studies to decrease thermal stress.

OPR: AL/CFTS, (210) 536-2937 [DSN 240]

Advanced pressure suit technology developments will improve mobility and dexterity, while operating at higher pressures.

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Aeromedical Evacuation Equipment Development

Medical equipment must be able to transit the entire casualty evacuation system. The environment onboard aircraft is considerably more hostile to equipment and patients than that of ground based hospitals. Equipment may be subjected to wide temperature changes, rapid changes in air pressure, and intense vibrations, along with unusual power supply problems and limitations. Additionally, demonstrations must prove that medical equipment proposed for air evacuation missions does not interfere with normal functioning of aircraft systems.

A variety of aeromedical items have been evaluated for customers across DOD. The equipment tested has been proposed for use by medical care providers for all phases of casualty care, with primary emphasis on air transport. Not only have off-the-shelf medical equipment items been evaluated, but also developmental prototypes and the test equipment itself. Ventilators, cardiac monitors, suction equipment, intravenous infusion pumps, and neonatal transport incubators are but a few of the many items which have been tested during the past year. Recent developments in the area of molecular sieve oxygen generation and ventilator control logic show potential for merging these technologies to provide unlimited medical quality oxygen on aeromedical evacuation airframes. This will significantly enhance the patient care capabilities of strategic aeromedical evacuation.

Air Mobility Command (AMC) has been tasked by DOD to transport sick and injured personnel during both peacetime and wartime. To provide the highest standard of care, AMC relies on state-of-the-art medical equipment which has been tested and found to be safe and reliable for use in aeromedical aircraft. HSC's Armstrong Laboratory is the only DOD laboratory which evaluates medical equipment to meet this standard. Benefits to the USAF are an increased inventory of medical equipment available to meet specific user needs, and the assurance that the equipment is safe for treating and monitoring acutely ill patients onboard USAF aircraft.

A vibration study is conducted on a C-9A to validate test criteria for air evacuation medical equipment.

OPR: AL/CFTS, (210) 536-2937
[DSN 240]

Molecular Sieve Oxygen Generating System

The B-1B Molecular Sieve Oxygen Generating System (MSOGS) separates oxygen from engine bleed air to produce a clean, oxygen enriched breathing gas for the aircrew. Oxygen is separated by adsorbing the nitrogen component of the bleed air onto a synthetic, aluminosilicate zeolite molecular sieve. The nitrogen is subsequently vented overboard. The B-1B MSOGS is presently being recertified since the type of molecular sieve will change in the near future, in that the original molecular sieve will no longer be manufactured. The Armstrong Laboratory (AL), working in cooperation with the Aircraft Program Office, the air logistics centers, and the aircraft contractor, is performing flight qualification testing and man-rating of the modified B-1B system. This testing will ensure the new system meets the aircraft specifications, and hence, produces acceptable oxygen concentration levels during all mission profiles.

This newly patented 99 percent MSOGS technology will be transitioned to the civilian sector. Near term technology transition plans include: licensing to a commercial company, initiating a Cooperative Research and Development Agreement to further develop this technology, and a Joint Research and Development Program with the US Navy to incorporate this technology in an AV-8B Harrier ground support unit. The current MSOGS is limited to generating oxygen concentrations of 93-95 percent, even under ideal conditions. The 99 percent MSOGS technology is capable of producing oxygen concentrations of up to 99.7 percent, satisfying the requirements of Military Oxygen Specification MIL-O-27210. This novel technology will represent the next generation of aircraft MSOGS systems.

AL scientists are pushing state-of-the-art MSOGS technology by advancing technologies which permit storage of large quantities of high-purity oxygen and improve MSOGS performance. Advances in miniature turbomachines for oxygen liquefaction will allow new systems to both generate and liquefy oxygen in a self-contained process. This liquefied oxygen will be used as a source of backup oxygen during the mission or for medical oxygen during aeromedical evacuation. MSOGS expert systems currently in development will revolutionize methods for improving MSOGS performance and will reduce engine bleed air consumption. These advances in MSOGS technology support AL's ultimate goal of delivering the best MSOGS technology to our users--the best aircrews in the world.

OPR: AL/CFTS, (210) 536-3361 [DSN 240]

Recertification of the B-1B MSOGS.

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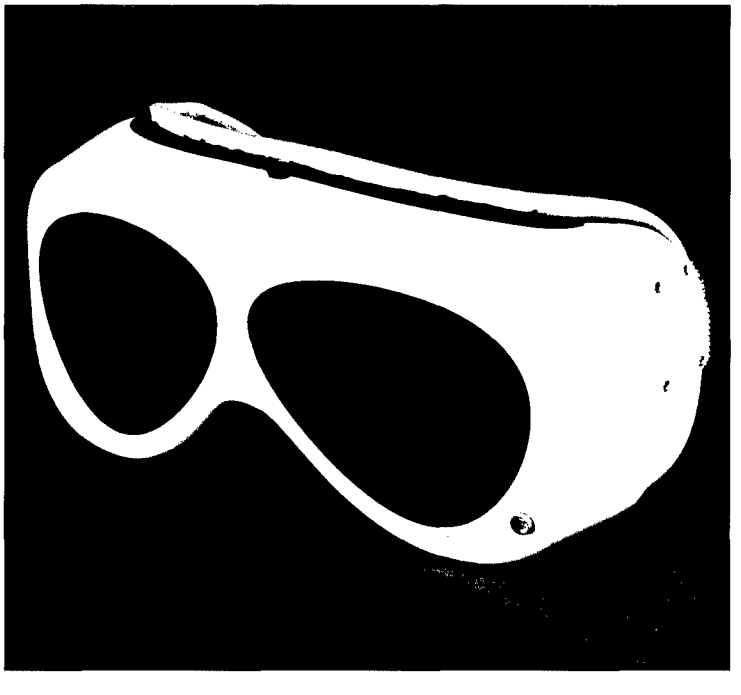
Thermal Flashblindness Protection Device System

The Thermal Flashblindness Protection Device (TFPD) system is designed to protect the aircrew member's eyes from flashblindness and retinal burns caused by the radiation from single or multiple nuclear flash events. Formal qualification testing on this off-the-shelf device is pending establishment of a clear use requirement. All test data collected will be analyzed, interpreted, and retained for potential future use. The TFPD utilizes state-of-the-art lanthanum-modified lead zirconate titanate (PLZT) similar to the lens in the current USAF flashblindness goggles, the EEU-2/P system. When the photo sensor senses the ambient light, reaching the level of a nuclear flash event, voltage is applied across the lenses causing them to become opaque. While opaque, the lenses shield the eyes from harmful light and radiation. Once the ambient light falls to a safe level, the lenses become clear again, restoring the crewmember's normal vision.

The system is small and lightweight, weighing approximately 5 ounces. Unlike the current inventory system, the TFPD has a self-contained power supply (a 12-volt battery) and fits under the visors of all standard issue flight helmets. It will be a welcome change from the bulky helmet-mounted EEU-2/P goggles.

OPR: HSC/YAS, (210) 536-2854 [DSN 240]



The TFPD system is small, lightweight, and fits underneath the standard issue helmet.

Laser Protection and Personnel Susceptibility

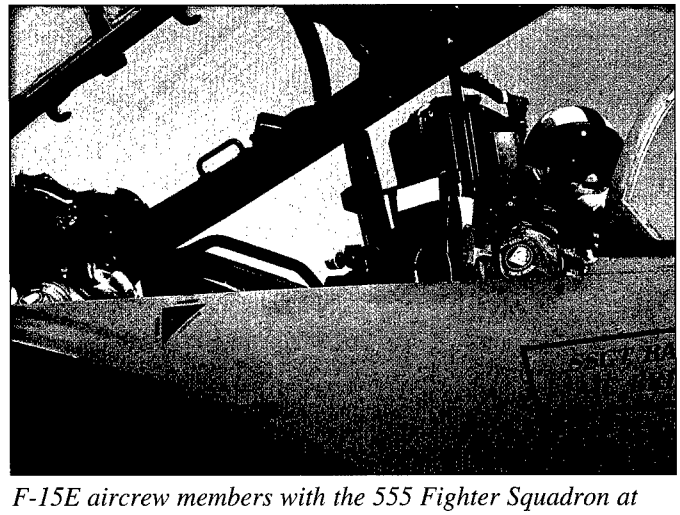
Optical technologies (e.g., lasers, optical munitions) could alter the air-land battlefield and enhance peacetime security operations. Third World nations could obtain low cost man-portable lasers for use as air defense weapons capable of defeating aircrew vision and aircraft sensors. Less than lethal effects could reduce wartime collateral damage or increase options to security forces for peacetime operations.

Exploratory and advanced development programs are underway to improve the modeling and simulation of personnel susceptibility and to transition new eye protection devices. The goals are to determine the vulnerability of personnel to optical technologies and develop protection devices suitable for many military operations. The protection program uses both mature technologies available from industry and advanced materials transitioned by the Wright Laboratory to develop devices that maximize protection and minimize human factors' limitations.

Prototype laser visors are being developed in the Advanced Aircrew Vision Protection (AAVP) program. The FV-6, developed rapidly for Operation Desert Shield/Storm, was the first multiline protection against invisible laser threats approved by HQ Air Combat Command for nighttime operations in the A-10 and F-16. The FV-6 is being modified for use in the F-15E. Aircrew concerns about compatibility with cockpit instruments, runway lights, and exterior aircraft lights, as well as threat identification, are being addressed through joint development, test, and evaluation at Edwards and Luke AFBs. Other AAVP program goals are to reduce the cost and maintenance requirements of laser visors, and to develop combination sun-laser visors. The modified FV-6 will be suitable for use by Special Operations Forces, and security, medical, and maintenance personnel.

Estimates of personnel susceptibility to optical devices and threats contribute to the requirements definition and vulnerability assessment processes. Personnel Effects Models (PEM) are being developed to enhance the reliability and accuracy of the estimates. Manned simulators have been used to assess the PEMs, such as was done during the Counter Target Acquisition Study (CTAS) II. CTAS employed networked fixed-wing simulators, in force-on-force, free play exercises, to determine the vulnerabilities of aircrews to laser air defense systems. By simulating the visual effects of laser exposure, CTAS enabled man-in-the-loop assessment of the military implications of laser weapons—without exposing personnel.

OPR: AL/OEO, (210) 536-3622 [DSN 240]



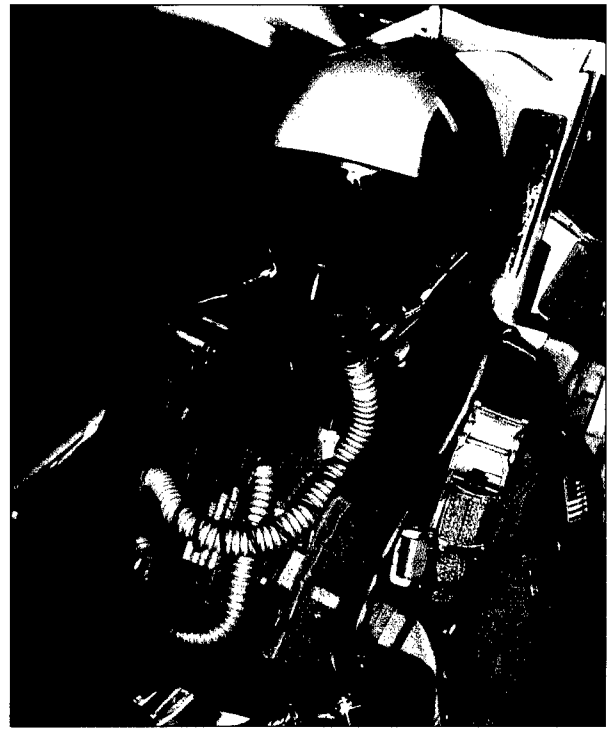
F-15E aircrew members with the 555 Fighter Squadron at Luke AFB, Arizona test new laser eye protection.

20

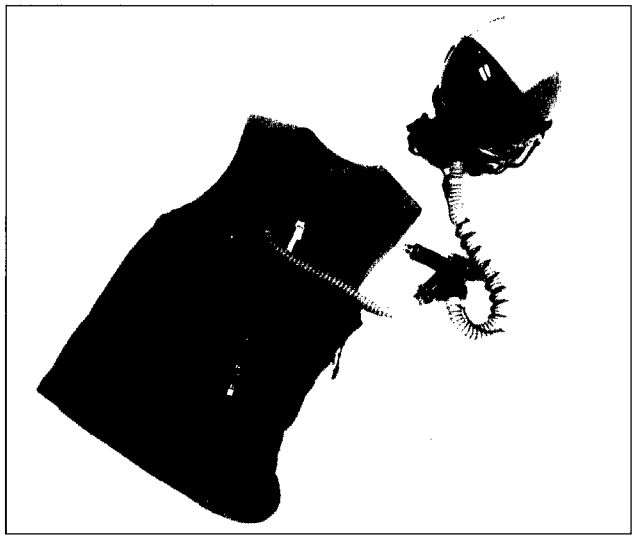
Combined Advanced Technology Enhanced Design G-Ensemble

The high-G maneuvers made possible by modern fighter aircraft can exceed the physiological protection afforded by traditional life support equipment and training. The combat crewmember must therefore restrict the aircraft's maneuvers to levels below the aircraft's full performance capabilities or risk suffering severe fatigue and possible unconsciousness. This fatigue can limit sortie surge capability, affecting flight safety and overall performance of the pilot.

In 1988, Tactical Air Command requested that a system be developed to provide F-15 and F-16 pilots enhanced protection from the negative effects of acceleration by incorporating a pressure breathing apparatus in conjunction with a currently fielded anti-G suit. This system is called Combined Advanced Technology Enhanced Design G-Ensemble (COMBAT EDGE). It uses a new oxygen mask, a counter pressure vest, a helmet modification kit, a new oxygen regulator, G-valve, integrated terminal block, and pressure sensor line for the aircraft.



Equipped with COMBAT EDGE, pilots can tolerate greater levels of "G" force.



COMBAT EDGE was certified Safe-to-Fly in 1990 following man-rating testing by Armstrong Laboratory. Development test and evaluation and operational test and evaluation flight tests in F-16 and F-15 aircraft were successfully completed in 1990 and 1991, respectively. Full rate production has commenced, and many F-16 units have already been equipped with this fatigue-fighting life support system.

OPR: HSC/YAS, (210) 536-2854 [DSN 240]

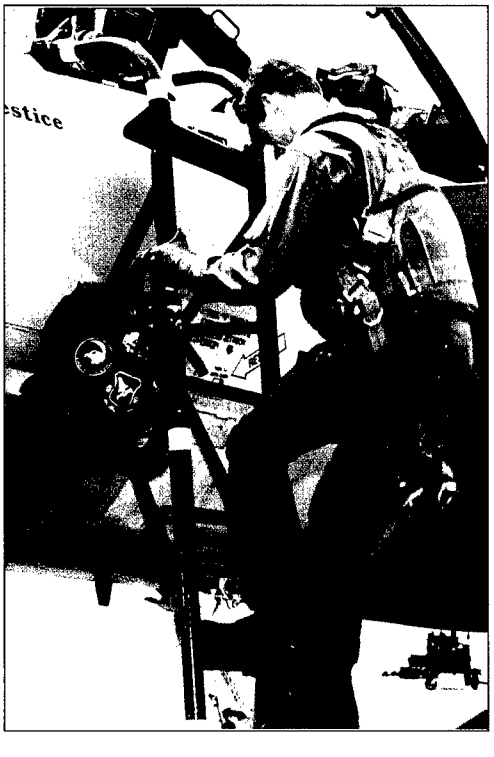
Advanced Technology Anti-G Suit

The anti-G suit used by USAF high-performance aircraft pilots represents technology dating back to the 1940's. The protective value of the current suit cannot match the high-Gz onset rate and sustained acceleration capabilities of modern aircraft. The Advanced Technology Anti-G Suit (ATAGS), developed by the Armstrong Laboratory, is intended to replace the currently fielded anti-G suit. No cockpit modifications are required for the system. The ATAGS can be used with or without Combined Advanced Technology Enhanced Design G-Ensemble (COMBAT EDGE). The ATAGS is a full coverage uniform pressure system designed to more effectively prevent pooling of blood in the lower body, one of the causes of the adverse effects of sustained acceleration. Full coverage means that counterpressure covers almost the entire lower body including the feet. Uniform pressure is achieved by surrounding the legs with pressure bladders rather than using smaller bladders and stretched fabric.

ATAGS reduces aircrew fatigue by decreasing the effort required for the anti-G straining maneuver. As compared to the existing suit, the ATAGS offers a 60 percent improvement in endurance during high acceleration—an indication of reduction in fatigue. When combined with COMBAT EDGE, a 450 percent improvement in endurance is seen. By reducing fatigue, fighter pilots can sustain performance during multiple air engagements and multiple sorties. During the past year the ATAGS has been significantly modified to improve comfort and operational acceptability. A series of man-rating evaluations (altitude, cockpit and equipment integration, and acceleration) were completed in preparation for an Early Operational Demonstration in cooperation with Air Combat Command. This demonstration consisted of a series of flight tests to collect using community comments before completing systems development. The ATAGS was successfully flown on more than 37 sorties in the F-15 at Langley AFB VA. The evaluation is continuing at Hill AFB UT in the F-16. Pilots using the ATAGS have been very enthusiastic about the tactical advantage offered by the suit. Transition to the Human Systems Program Office began in 1993.

The ATAGS addresses the most pressing problems associated with high-acceleration flight—performance compromise and G-induced loss of consciousness. By providing the crewmember with superior life support systems such as ATAGS, combat capabilities will improve while loss of lives and aircraft will decrease.

OPR: AL/CFTF, (210) 536-3811 [DSN 240]



ATAGS produces increased pilot tolerance to the high-G environment.

Aircrew Life Support

The Armstrong Laboratory (AL) Crew Technology Division is heavily involved in development programs for advanced aircrew life support and protective equipment. Recent advances in aircraft operational demands and capabilities have necessitated adding protective equipment, resulting in an increasing burden on the aircrews. In addition to the traditional flight gear and life support equipment for altitude, acceleration, hearing protection, and egress and survival, the aircrews are now being laden with systems for chemical/biological and enhanced acceleration protection, passive antidrown capability, helmet-mounted electro optical devices, and laser/flashblindness protection. The Cockpit and Equipment Integration Laboratory (CEIL) of the AL Crew Systems Division has been providing essential input concerning possible integration problems and proposed solutions.

Test subject conducting water immersion tests wearing an experimental anti-G suit and full complement of aircrew personal protective equipment.

Collocated with the USAF Life Support Systems 6.3 Advanced Development Program Office, and associated with the Human Systems Program Office at Brooks AFB TX the Cockpit and Equipment Integration Laboratory has conducted tests and evaluations on several new systems. As an integral part of the Advanced Technology Anti-G Suit Development program, the CEIL was instrumental in identifying critical design problems early, which limited emergency egress by larger crewmembers. Due to the involvement of cockpit integration early in the program, needed design changes can be accomplished with minimal impact on schedule and costs, and will result in increased user acceptance and reduced risk for the 6.4 Engineering Development program. The CEIL also tested an early design of an integrated positive pressure for G and chemical protective systems, a proposed active noise reduction system, a hose modification to the Aircrew Eye/Respiratory Protection hood/mask, and two versions of modified masks for the Combined Advanced Technology Enhanced Design G-Ensemble. Evaluation of equipment within the CEIL allows problems to be identified prior to costly flight trials.

As new systems are proposed and advances made in future aircraft capabilities, emphasis on equipment integration and design optimization will continue to be a basic element of the AL Crew Technology Division's mission. Future direction focuses on alleviating the burden on aircrew members by developing novel approaches to combined protective capabilities and reducing the volume of equipment to be worn.

OPR: AL/CFTS, (210) 536-3361 [DSN 240]

Life Support and Chemical Defense Sustainment

Life Support was the USAF's "first" cradle-to-grave single manager concept to be approved by the Secretary of the Air Force for Acquisition under the Integrated Weapon System Management concept. The single manager, HSC/YA, through the Kelly AFB System Support Manager, continues to provide first-class real time field support to operational USAF units worldwide. With responsibility for all USAF life support equipment, parachute and egress equipment, and fixed seat safety restraints in cargo aircraft, the division successfully maintained the war readiness posture of all flying units. Besides the active USAF commands which depend on the over 7,000 stock issue items that YA provides, the US Army, US Navy, NASA, Department of Transportation (forest fire fighters), and over 70 different foreign countries that purchase life support military hardware from the US Government are supported.

With annual expenditures of over $50 million, an average month of acquisition activity typically includes awarding approximately 40 contracts.

The HSC/YA division is composed of five integrated product teams (IPT): Egress, Survival Equipment, Fixed Seats, Mishap Investigation, and Chemical Defense and Electronics. Each team has assigned logisticians, equipment specialists, item managers, engineers, and contracting officers. The recent conversion to IPTs has proven invaluable, since manpower has been reduced by defense downsizing.

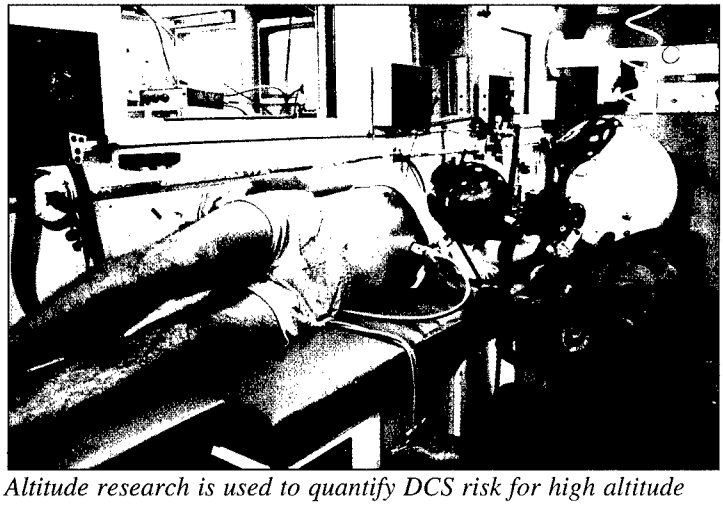
The "single manager" leadership style of development and sustainment has already identified better methods to support fielded equipment like COMBAT EDGE and AERP. This "up front and early" interaction significantly reduces the life cycle cost of both products. Additionally, close working relationships laid the groundwork for the future acquisition of solid and reliable systems for all of our customers.

OPR: HSC/YAD, (210) 925-3756 [DSN 945]

Supporting flight operations requires that over 7,000 items of life support gear be maintained, improved, and available to the airmen in the field.

High Altitude Protection Research Program

Crew operations in high altitude aircraft and space vehicles require protective measures to overcome the physiological hazards of the hypobaric environment. Goals of the Armstrong Laboratory's High Altitude Protection Research program are aimed at defining safe exposure limits and supporting development of crew protection equipment and procedures. The research program is currently focused in three areas: pressure breathing, decompression sickness (DCS), and effects of exposure to extreme altitude (ebullism).



Altitude research is used to quantify DCS risk for high altitude and spaceflight.

A recent survey of U-2 pilots indicates that 60 percent have experienced DCS in flight. Altitude chamber simulations show a 73 percent incidence of DCS for a typical U-2 flight profile. Although DCS risk can be reduced by prebreathing 100 percent oxygen prior to takeoff, requirements for rapid sortie generation and extended missions limit the amount of time available for prebreathing. To provide improved DCS protection in these situations, the concept of in-flight denitrogenation was experimentally demonstrated and recently transitioned to Air Combat Command in support of the high altitude reconnaissance mission. This concept can also provide significant improvements in crew protection during high altitude airdrop missions. A computer based decompression model is being developed to standardize DCS risk assessment. A first generation model has been demonstrated and continued development, including verification and testing, is underway. Very little data concerning DCS limits for exposures above 30,000 feet are available; experimental studies are planned to fill this critical void. At these altitudes, positive pressure breathing is required for hypoxia protection. The physiological effects of this procedure on pulmonary functions are being investigated.

The High Altitude Protection Research Program provides a critical part of the technology base necessary to successfully accomplish the USAF mission of defending the US through control and exploitation of air and space.

The results of these research efforts are transitioned to operational commands in the USAF and NATO, as well as to Air Force Materiel Command System Program Offices involved with life support equipment and the development of future high altitude aircraft and transatmospheric vehicles. Results of this research are also transitioned to NASA in support of manned space programs.

OPR: AL/CFTS, (210) 536-3545 [DSN 240]

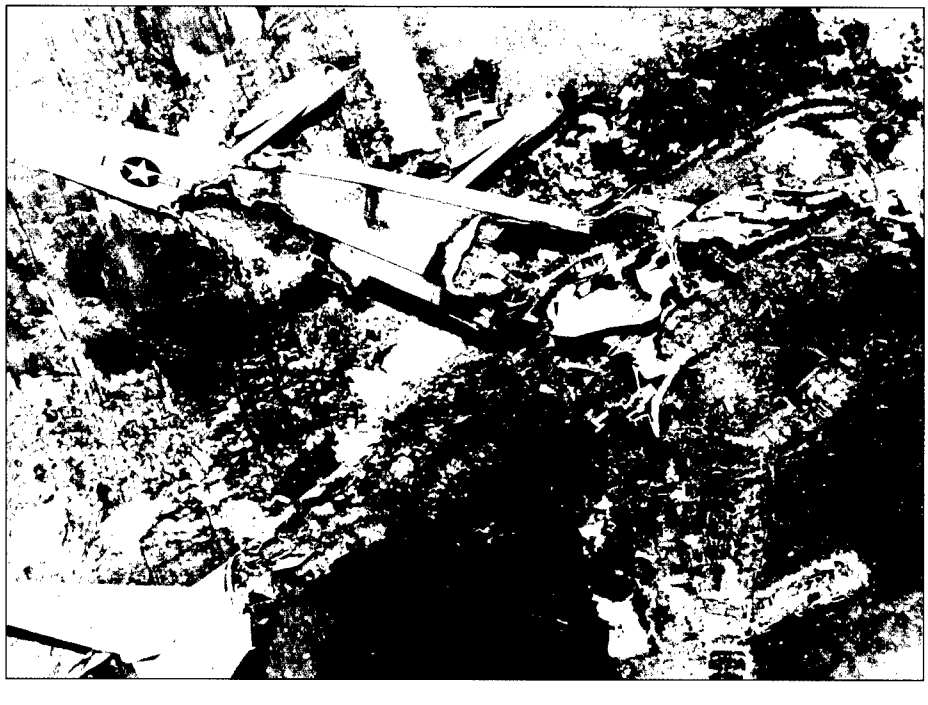
Aircraft Mishap Prevention System

Human factors contribute to more than two-thirds of the USAF's most serious class of mishaps. As a consequence, the annual costs are estimated to exceed $900 million with a loss of human life approaching 60 aircrew fatalities. The Air Force Safety Agency (AFSA) and mishap boards document human factors which lead to mishaps, but the exact significance and correlation of any specific factor in a mishap remain difficult to analyze. The Aircraft Mishap Prevention (AMP) system will be an automated tool designed to support the AFSA staff in collecting and analyzing human factors data related to aviation mishaps.

The AMP system is a distributed computer network which consists of two file servers, 25 workstations, a scanner, and associated peripherals. It will provide continuity and corporate memory by making human factors information readily available in a centralized repository. The AFSA analysts will use the AMP system to perform proactive analyses which solve difficult human factors problems and reduce aircraft mishaps by suggesting more effective preventive measures.

The AMP system will demonstrate an initial operational capability by FY94. When fielded, it will allow AFSA a more timely and comprehensive understanding of human factors in aircraft mishaps. It will have the flexibility and growth potential to accommodate future technology. By conservative estimates, the AMP system has the potential to reduce the aircraft mishap rate by 10 percent over a five-year period. The lives that will be saved are invaluable.

OPR: HSC/YAR, (210) 536-2477 [DSN 240]



Aircraft mishaps due to human factors can be significantly reduced, saving lives and resources.

Universal Water Activated Release System

Ejection from aircraft over water introduces additional hazards to the crewmember which are not primary concerns when ejecting over land. If the individual is unconscious or incapacitated, or if there are high surface winds or rough seas, the risk of drowning is significant. The current automatic parachute release system (AFSEAWARS) prevents the crewmember from being dragged through the high seas, but it is not compatible with the Capewell parachute release system used in the B-52 and KC-135. In addition, the AFSEAWARS failed to satisfy its reliability requirements, and its bulky design bruises crewmembers' arms. A follow-on system, the Universal Water Activated Release System (UWARS), alleviates these situations by providing a lighter, smaller, in-line device with increased reliability that is compatible with the Capewell, Frost, and Koch parachute release systems.

Compared to the AFSEAWARS, the new UWARS is significantly more streamlined and comfortable to wear.

UWARS incorporates the following technical improvements using 1980s and 1990's technologies: a semiconductor bridge initiator as the electro-explosive device; a printed circuit board; surface mount components; and a built-in test for battery voltage, polarity, and circuit continuity. UWARS requires low maintenance primarily limited to replacement of the batteries which will be stock listed items.

The UWARS development contract was awarded by the Human Systems Program Office in September 1991, the Critical Design Review was conducted in July 1992, and Development, Test and Evaluation (DT&E) started in February 1993. Operational Test & Evaluation and an option for production will follow DT&E.

OPR: HSC/YAS, (210) 536-2854 [DSN 240]

Advanced Recovery Sequencer

A recent adverse-flight conditions mishap of an A-10 aircraft outside the performance capability of the current ACES II ejection seat resulted in insufficient altitude for the parachute to fully open. Computer simulation of the mishap showed earlier deployment of the parachute may have saved the pilot. Consequently, the Accident Board recommended that a development program be initiated to investigate earlier parachute deployment at low altitude and moderate speed conditions.

The Advanced Recovery Sequencer (ARS) uses digital electronics coupled with electronic pressure transducers to more accurately determine the altitude and airspeed at the time of ejection. This information is fed to the sequencer and sets off a sequence of events to stabilize the seat once it has departed the aircraft. The ARS consists of two modules: the power module contains all the items necessary to provide power to the sequencer and the logic module contains all of the microprocessors and memory chips needed to process and store information. A major feature of the ARS is its ability to store the exact pressures and ejection times that existed at the time of ejection.

The ARS has improved maintainability. Intermediate- and depot-level test capability is built into the ARS. The power module and the electrical lines are replaceable at the intermediate level. The life of the ARS is 22.5 years, which represents a significant improvement in efforts to reduce life cycle costs of these types of components.

The ARS is fully qualified and is now scheduled for spare procurement for A-10, F-15, and F-16 aircraft; furthermore, it will be incorporated in the production seat for future F-16 aircraft. The ARS has even been identified as a baseline configuration requirement for the F-22 aircraft, and it represents the USAF's fervent pursuit of better and smarter ways to help save the lives of its aircrews.

OPR: HSC/YAD, (210) 925-3756 [DSN 945]

The ACES II seat lands at Holloman AFB, NM after a successful ejection test of the recently installed "Advanced Recovery Sequencer." Twenty-two seat ejections were accomplished for qualification of the seat with this critical new component.

Life Sciences Equipment Laboratory

The Life Support Mishap Investigation Lab is operated by the Human Systems Program Office's Life Support System Support Manager at Kelly AFB TX. USAF mishaps are investigated quickly, and technical reports and corrective actions are recommended. Board presidents, flight surgeons, and life support officers assigned to the mishap boards interface daily during active investigations. Annual training is provided for over 200 life support officers, life support superintendents and egress supervisors, thereby ensuring this core group can perform the first-level field investigations. The Mishap Investigation Lab ensures that one researcher is always available 24 hours a day to provide mishap boards with requested field expertise.

The lab maintains data and accident investigation histories (in accordance with AFR 110-14) to identify trends which could lead to future injuries or fatalities. All such deficiencies are immediately worked by the System Support Manager for correction via Technical Change Orders, equipment modifications, or recommended operational limitations.

The lab was established in 1983 and processes approximately 25 Class A mishaps annually. Extensive test procedures are developed to measure and interpret the various exhibits sent in for analysis. The full spectrum of metallurgical, dimensional, nondestructive inspection, fabric, chemical, and physical labs at Kelly AFB TX are fully available and easily energized to support these tests.

Recent assistance has been provided to the Joint Task Force for Full Accounting (JTFFA). This investigating team is charged with determining the status of missing in action in Vietnam. Several cases of national interest have been validated by the Mishap Lab's scientific methods applied to the remnants of life support equipment which have been discovered and returned for analysis. These analyses provided critical information supporting the JTFFA's cases and ensured that the necessary closure data could provide meaningful answers to concerned families.

OPR: HSC/YAD, (210) 925-3756 [DSN 945]

Discovering clues to the cause of any aircraft mishap often requires the expertise of the Life Sciences Equipment Lab.

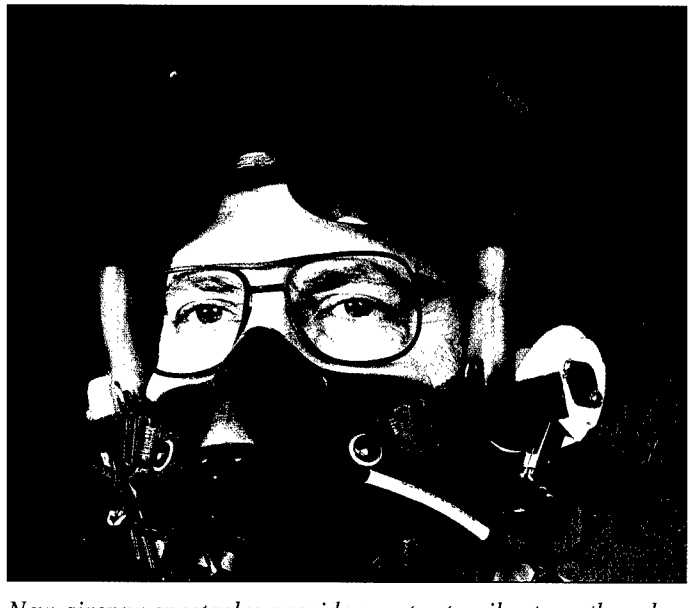
Aircrew Spectacles

In 1990, a Human Systems Center study determined that 27.4 percent of USAF pilots and 51.5 percent of Navigators/ Weapon Systems Operators were spectacle wearers. HSC is responsible for developing optical devices for correction of aircrew vision and for integrating these devices with life support systems. The present aircrew spectacle frame, the HGU-4/P has been in the USAF inventory since 1958. Although the HGU-4/P has served well, there have been several significant advances in spectacle frame materials and design. The Armstrong Laboratory Ophthalmology Branch of the Clinical Sciences Division (AL/AOCO) was asked to find a sturdier frame that would be compatible with most life support systems and would have a wider field of view.

The attributes of the "ideal" aircrew spectacle frame were gleaned from a 1991 spectacle frame field study. An off-the-shelf prototype spectacle frame that possessed most of these attributes was chosen for further testing and evaluation. The new prototype aircrew spectacle frame meets ANSI Z-87.1 safety standards and has a flat black finish to reduce reflections and glint. It also has silicone nose pads for comfort and stability on the face when sweating or under G-acceleration. The larger eyesize of the new frame gives a wider field of view than the HGU-4/P. However, the total horizontal measurement of the new frame is less than that of the HGU-4/P which should make it more compatible with most life support systems. This was accomplished with a new wraparound hinge design.

AL/AOCO and the Air Warfare Center (AWC/TCO) at Eglin AFB FL will jointly field test the new aircrew spectacle frame. The frame will be evaluated for compatibility with life support systems, comfort (hot spots, weight, fit), stability on the face during G-load, acceptance by aircrew members, durability, reflections, field of view (checking six), and ease of adjustment by optometry technicians. Upon successful completion of testing and certification by the AWC, the aircrew spectacle frame will be recommended to the HQ USAF Surgeon General as the tri-service replacement for the HGU-4/P.

OPR: AL/AO, (210) 536-2745 [DSN 240]



New aircrew spectacles provide greater tensile strength and better field of view.

30

Infrared Voice Communications

Acoustic noise poses a serious problem for effective voice communications in operational environments such as chemical defense, aircraft maintenance, aircraft quick turnaround, cargo loadmaster, and emergency medical care. An Infrared (IR) voice communications system is being developed to provide personnel who perform tasks in these environments with the high level of intelligibility required for mission accomplishment.

The IR system is a portable man-mounted voice communications system designed to operate with headsets and boom or mask microphones. The system provides a highly intelligible voice channel in conjunction with the noise attenuation provided by the headset. This allows the wearer to communicate with others wearing like systems in high noise environments. The lightweight transmitter/receiver mounts on the top of existing headsets and uses the standard microphones already fielded. The walkie-talkie sized electronics and rechargeable battery module mount on a belt. Since the system uses infrared light energy, it does not cause interference with radio frequency systems already in use for air base operations. Also, the transmission medium makes the system inherently jam resistant. The directional transmit range of the system is approximately 150 feet.

Demonstration models of the IR system technology have proven successful. The full design will include active noise reduction, omnidirectional transmit and repeater capability. The omnidirectional capability will allow personnel to operate at close range without the added task of aiming the IR beam. The directional transmit capability will be utilized for distant communications. The repeater system will be a portable module that will retransmit IR signals for extended range and allow communications around objects that would normally be obstructions in the IR transmission path.

The development of the IR communications system will result in better voice communications for personnel in high noise environments for the accomplishment of their missions. This technology can also be applied toward the development of voice communication systems in low noise environments such as military police and surveillance where portability and detection avoidance are requirements.

OPR: AL/CFB, (513) 255-3660 [DSN 785]

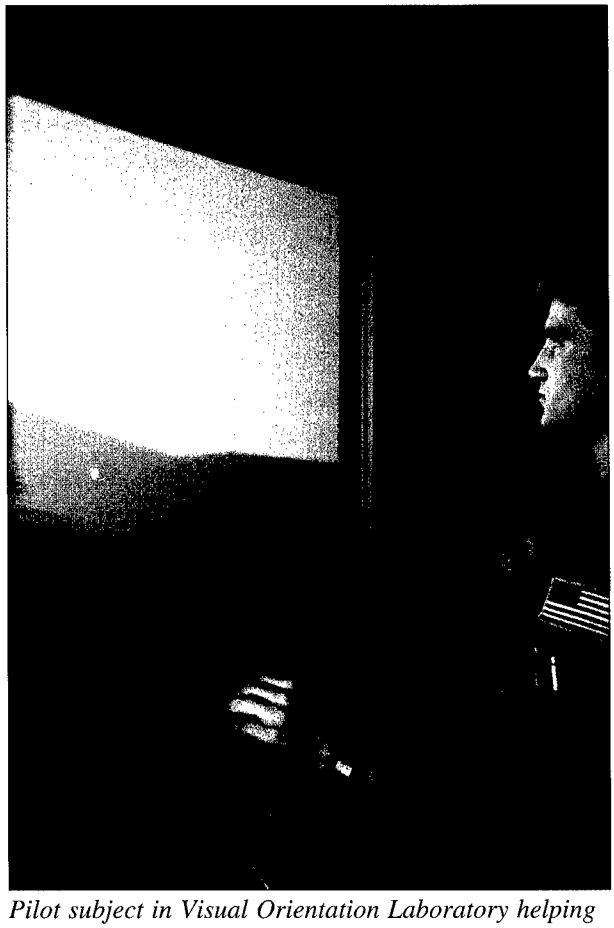
The IR voice communicator provides more intelligible communications in a high noise environment.

Heads-Up Display Symbology Evaluation

As a result of a series of aircraft accidents attributed to deficiencies in primary flight instrument symbology, HQ USAF/XO directed that cockpit displays, particularly Heads-Up Display (HUD) symbology, be optimized and standardized. Further emphasis on improving and standardizing primary flight displays was provided by the USAF Chief of Staff.

Armstrong Laboratory researchers compared, under rigidly controlled testing conditions, the HUD symbology elements to be evaluated. In the Visual Orientation Laboratory, USAF pilots participated in experiments requiring them to do precision instrument control tasks, unusual attitude recoveries, and instrument approaches while using various HUD symbologies. Ranking of efficacy of competing symbologies was based strictly on the pilots' performance while using them, but subjective ratings of the symbologies were also obtained.

The laboratory testing resulted in the following recommendations for standardized HUD symbology: (1) rotating pointers plus digits (counterpointers) for airspeed and altitude; (2) a variable-length arc around the altimeter for vertical velocity; (3) a climb/dive ladder with vertical and horizontal asymmetry (articulated bottom, tapered top, and left-side-only pitch numbers); (4) a "ghost" horizon to show the direction of the true horizon when the latter is outside the HUD field of view; and (5) "worm" and "caret" symbols for angle of attack and airspeed change rate, respectively. The recommended symbology elements were subsequently integrated into a draft standard symbology suite that was subjected to full-flight simulation and ultimately in-flight validation. As a result of successful completion of these phases, the recommended symbology will be incorporated into Military Standard-1787, Aircraft Display Symbology.



Pilot subject in Visual Orientation Laboratory helping to evaluate Heads-Up Display (HUD) symbology for standardization.

Flight display symbology development will continue in Armstrong Laboratory as improvements to the standard HUD symbology are proposed and as work progresses on optimizing and standardizing head-down and head-mounted flight instrument displays.

OPR: AL/CFTF, (210) 536-3521 [DSN 240]

32

Night Vision System

Modern warfare has led to an increase in airborne combat under the cover of darkness. Night missions include ground operations, takeoffs and landings in complete darkness, lights-off air refueling, and visual acquisition and identification of enemy targets hidden under the night sky. The current emphasis on flying aggressive missions with little visible light mandates that aircrews be able to see in ways that the human eye cannot. Devices called Night Vision Goggles (NVGs) currently exist and provide enhanced situational awareness for aircrews at night. Although NVGs permit operational effectiveness during these types of low-light operations, they are not safe to wear during an ejection from an aircraft. For that, and other reasons, an improved capability was required.

In 1988, Strategic Air Command requested the development of a Night Vision System (NVS) which would provide at least the same optical performance available from the currently used NVG known as ANVIS-6, but which would be lightweight, low profile, and ejection safe. Several other commands interested in improving their edge during low-level navigation, stealth operations, and target acquisition have cosponsored the program. The scope of this program now includes supporting bomber, attack, fighter, tanker, cargo, and helicopter, and various special operations for aircrews.

Two competitive contracts were awarded in 1993 for prototyping night visions systems. With the fielding of this advanced hardware, the safety of night training, the survivability of night missions, and the effectiveness of combat operations will be further enhanced.

OPR: HSC/YAS, (210) 536-2854 [DSN 240]

The Night Vision System provides an improved capability to see in low light/night conditions.

Aviation Night Vision Goggle Concept

The effectiveness of Night Vision Goggles (NVG) needs to be improved in several areas before the NVG can truly be adaptable for aircrew member use. In particular, improvements are needed in visual resolution (acuity), field of view, weight, and center of gravity. Enhanced night vision goggle designs are being explored through a Small Business Innovation Research (SBIR) effort. The program is being managed out of the Armstrong Laboratory Visual Display Systems Branch at Wright-Patterson AFB OH and has yielded some promising results.

Phase I explored alternative optical designs, with one chosen as optimum and selected for fabrication under Phase II. The Phase II design, currently called "Concept VI," has a minimum profile, adapts to the standard USAF issue helmet, and will fit underneath the helmet visor. A goal is for the NVG to be maintained on the helmet throughout the entire escape sequence for both ejection compatibility as well as use during descent. Anthropometry considerations, which are vitally important but often ignored, were implemented early in the design process. This has resulted in several independent adjustment features which provide an excellent optical fit. New and improved "hot" image intensifier tubes are part of the Concept VI design, allowing a wider field of view (45 degrees) and better visual acuity (20/26).

These critical performance parameters are far better than currently fielded systems, and offer a significant increase in night-fighting capability. The results of this SBIR effort are being supplied to the Helmet-Mounted Systems Technology Advanced Development Program Office and Human Systems Center Night Vision Systems Program Office for incorporation into their efforts.

OPR: AL/CFHV, (513) 255-7592 [DSN 785]

New NVG design fits underneath issue helmet and provides improved visual acuity.

Vista Saber II

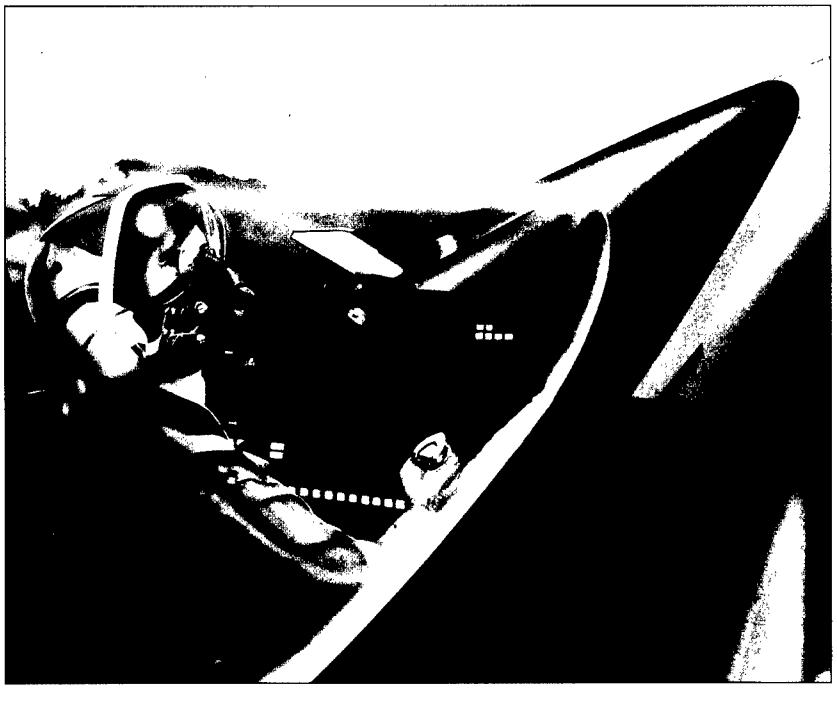
Future air battles will increasingly rely on more advanced aircraft capable of directing their weapons with greater accuracy and at larger off-boresight angles. Analysis of current threats indicate that some potential adversaries already include some of this enhanced technology in their aircraft today.

Helmet-Mounted Displays and Sights (HMD/S), combined with an agile missile, provide a capable response to that threat. These systems let the pilot lock on to targets and fire missiles at much greater angles than normally allowed in the Heads-Up Display. The HMD also provides the capability to display other important and time critical information at any head orientation. No longer will the pilot have to look inside the cockpit to determine weapon status, airspeed, altitude, or general aircraft attitude, resulting in an increase in situational awareness and combat effectiveness.

The Vista Sabre II program effort is to install two helmet-mounted displays/sights on two F-15C aircraft to demonstrate the capabilities of this technology in air-to-air combat. The Visual Display Systems Branch of the Armstrong Laboratory Crew Systems Directorate has teamed with the 57th Test Group at Nellis AFB NV and the F-15 Engineering Group at Warner-Robins AFB GA to conduct this effort. The two aircraft are being modified by McDonnell Douglas Aircraft of St Louis MO to incorporate the Kaiser Electronics Agile Eye HMD and associated display electronics. The electronics will interface with other aircraft avionics and present a see-through 20-degree field of view projected on the helmet visor graphically overlaying the line of sight of the pilot's right eye.

The HMD/S will help the pilot locate a target faster, lock a missile onto that target, and simulate the missile launch. Previous simulator studies have shown significant improvements in aircraft kill ratio. This program will demonstrate the technology during actual flight tests. During this time, the system will be evaluated through all aspects of the close-in visual combat arena.

OPR: AL/CFHV,
(513) 255-7594 [DSN 785]



Vista Saber II is a field evaluation of a Helmet-Mounted Display/Sight system.

Force Reflection Stick Controllers

As pilots are subjected to accelerations greater than 1-G, arm/hand loadings are fed through to current analog and digital (fly-by-wire) stick controllers. These severe motions can adversely affect the pilot's tracking ability. Data from high-G centrifuge tests revealed that when acceleration forces opposed the stick displacement, tracking performance improved substantially.

A test bed facility showed conclusively that reflecting a force back opposite the hand motion, based on measurements of the external acceleration, provides smoother tracking responses. Presently, a second generation stick controller is used daily by handicapped people at the St Elizabeth Hospital in Dayton OH as part of a joint Armstrong Laboratory/Veterans Administration program. This program provides an extensive database for both pilots in static and acceleration situations and disabled people who need to control their spasticity.

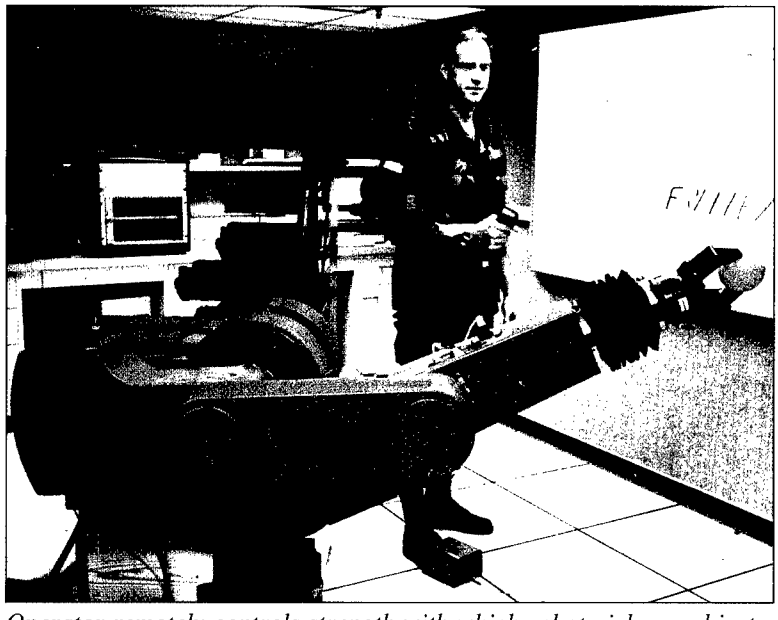
Force reflection offers great promise in manual control with applications to controllers for aircraft during the high acceleration maneuvers typical of modern agile fighters, wheelchairs, and heavy equipment operations. Any exercise involving tracking where hand or arm motion may be disturbed by the environment or induced by neuromotor disorders can be improved by force reflection controllers.

OPR: AL/CFBS, (513) 257-5742 [DSN 787]

Force reflection provides smoother tracking during random arm movements.

Force Reflection for Human Sensory Feedback

Telerobotic systems provide the capability to project human presence, cognition, and intuition into environments that would be lethal to human workers. High fidelity human-in-the-loop control of telerobotic systems requires natural intuitive feedback for the human operator. A key component to the successful operation of these remotely controlled systems is the use of force-reflection methods to give the operator the sensation of "presence" at the hazardous work sites. Natural intuitive force reflective feedback augments visual and auditory feedback in the unstructured work environment. The development of a Force REFLecting EXoskeleton (FREFLEX) has been a prime goal of the Human Sensory Feedback program.



Operator remotely controls strength with which robot picks up object.

Odetics, Inc., has developed a FREFLEX to support human sensory feedback research at the Crew Systems Directorate at Wright-Patterson AFB OH. The FREFLEX was delivered in June 1992. The system is designed to take full advantage of the human's seven degree-of-freedom shoulder, arm, and wrist movements. Data such as force reflection ratios, range of motion measurements and system encumbrances will be collected over the next three years. These data will support human factors design of the next generation of telepresence subsystems.

In addition to providing design information for master-slave telerobotic systems, this force-reflection device has applications in synthetic environments where direct interaction with simulations and virtual models are desired.

Land based applications include toxic chemical handling and environmental cleanup. Additional uses can be envisioned in nuclear, biological, or chemically contaminated environments such as post-attack cleanup in air base operations.

Space based operations include satellite refueling and servicing, as well as unstructured repair and maintenance functions.

OPR: AL/CFBA, (513) 255-3671 [DSN 785]

Active Noise Reduction

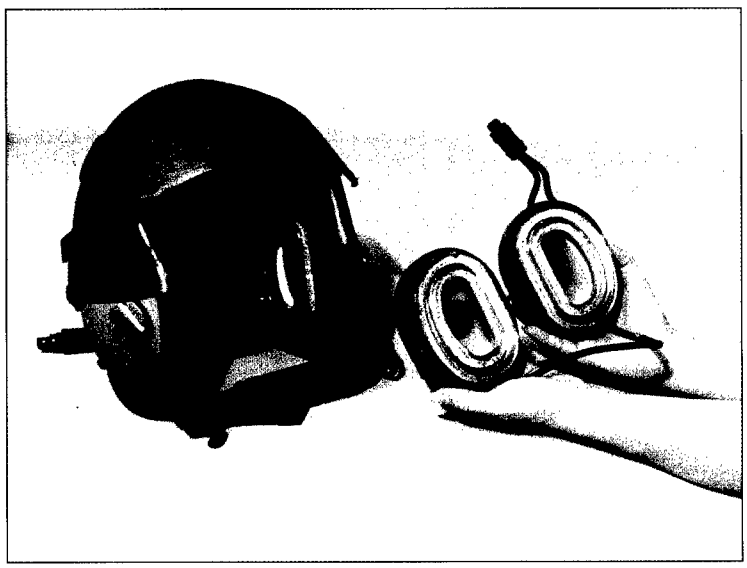
Operational testing of the HGU-55/P flier's helmet determined communications were minimally acceptable as the earcup permitted excessive background noise to be heard by the wearer. An electronic technique called noise phase reversal has been devised to significantly attenuate much of this unwanted sound, and the device has been packaged so that it does not exceed the restricted size of a helmet earcup. This technique creates an out-of-phase sonic signal that acoustically cancels noise within the earcup, thereby improving voice communication in noisy environments and reducing fatigue to the crewmember caused by the noise.

The Active Noise Reduction (ANR) system electronics are installed in the new earcup and are provided as a direct replacement for the current earcups used in existing helmets and headsets.

Prototypes were developed during an advanced development program and tested by all three services with excellent results. An engineering development test and evaluation program is ongoing.

The ANR system will reduce the number of aircrews grounded because of hearing loss, and that, in turn, should decrease the number of related compensation claims. More importantly, this program will provide the USAF and other service aircrews a system which provides greater attenuation of undesirable sound with a simultaneous increase in communications capability, reduced fatigue, and greatly improved mission effectiveness. An additional opportunity exists for use of this type of system in loud/high noise level environments on the ground, thereby further reducing legitimate medical claims for hearing loss.

OPR: HSC/YAS, (210) 536-4538 [DSN 240]



The Active Noise Reduction earcups, as installed in an aircrew helmet (HGU-55/P), will electronically reduce annoying or distracting background noise.

3-D Audio Display System

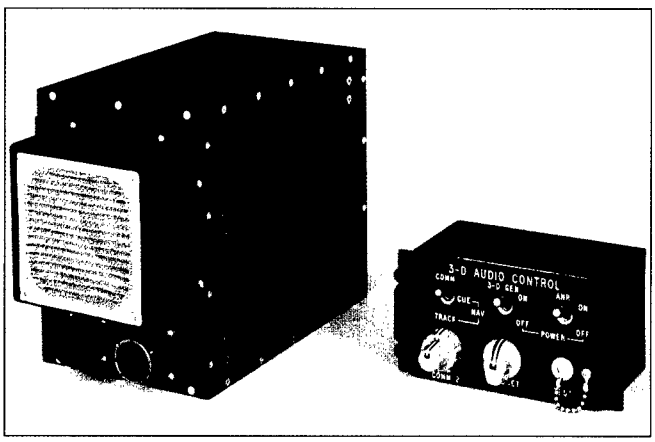
Situational awareness (SA) is critical to all aircrews. The 3-D Audio Display system has the capability to improve SA without adding any new signals to the cockpit or requiring any new skills. This is achieved by processing existing cockpit audio signals, such as radar warning receiver tones; wingman voice communications; other radio voice communications; and navigation tones, such that the crewmember hears signals which sound as if they are coming from specific locations in azimuth, elevation, and distance, i.e., a virtual 3-D auditory display. Presenting the signals in this manner takes advantage of the crewmember's natural ability to localize sound sources. This ability is demonstrated every day by people standing on a street corner determining the location of a vehicle approaching from the rear or from outside their current field of view.

Flight demonstration hardware has been developed which can generate up to four localized auditory signals simultaneously from any audio source. The 3-D Audio Display system uses a two-channel headset, and one independent earphone for each ear. The 3-D auditory cues are stabilized in space relative to the aircraft boresight and crewmember's head position. This is accomplished using the aircraft's flight or mission computer, navigation system, and a helmet-mounted head tracking system. The 3-D Audio Display system adds approximately 3 ounces to the helmet and approximately 12 pounds to the aircraft.

The flight demonstration hardware and software development have been completed. The system, with an interface control document, has been safety tested for flight test aircraft. Laboratory studies demonstrated the utility of the 3-D Audio Display system. Crewmembers using the system can locate targets with an average error of less than 10 degrees. Target acquisition times with normal visual radar warning display locations are significantly reduced using the system. Further, the system significantly enhances voice communications in all communications environments.

The 3-D Audio Display system is one technology which can increase SA without increasing aircrew workload. The increase in SA and communication capability results in improved mission effectiveness and survivability.

OPR: AL/CFB, (513) 255-3660 [DSN 785]



3-D Audio Display system increases SA without increasing workload.

Integrated Audio Technology Demonstrator

The Integrated Audio Technology Demonstrator (IATD) is a lightweight helmet in which several emerging audio technologies have been integrated for laboratory demonstration and data collection and use in high fidelity flight simulators. These technologies include active noise reduction, 3-D audio displays, advanced noise-canceling microphones, helmet-position monitoring, and a lightweight helmet shell. Two other concepts were investigated but not integrated into the final configuration. These were an ear microphone concept and a G-loss of consciousness onset monitor and warning system. These additional concepts may be integrated at a later date if their development for this application is successful. Six copies of the IATD have been fabricated to support both laboratory performance verification tests and technology demonstrations.

The IATD helmet development and laboratory performance verification have been completed. A complete battery of tests verified the helmet system's performance in high performance aircraft cockpit noise environments. The success of the laboratory studies led to flight demonstrations of the integrated IATD in the Navy/Marine T-1 AV-8B located at the Patuxent River Naval Air Station.

Voice communications significantly improved through use of the Integrated Audio Technology Demonstrator.

Performance verifications have demonstrated increased pilot performance in several critical areas. The 3-D audio display function dramatically reduced target acquisition times. Voice communications were significantly improved by both the active noise reduction headset, 3-D audio display, and advanced noise-canceling microphones. The active noise reduction headset not only provided increased comfort, but also decreased pilot fatigue.

OPR: AL/CFB, (513) 255-3660 [DSN 785]

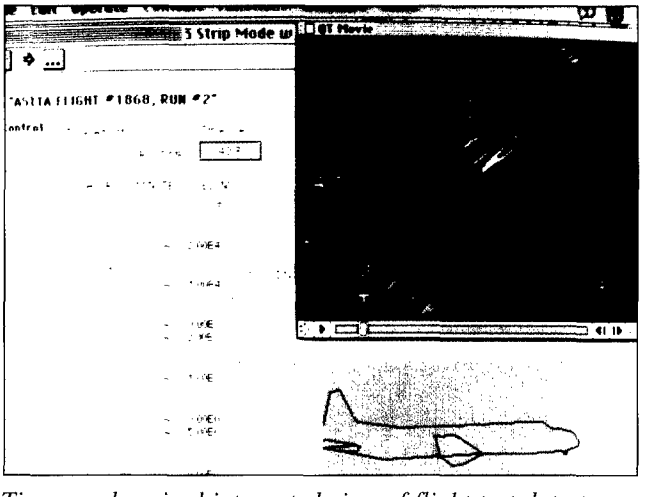
Performance Assessment and Workload Evaluation System

Critical to piloted aircraft flight testing is the assessment of the crew station and the cockpit design in terms of the aircrew's ability to meet mission objectives. Currently, no standard process for this aspect of flight tests exists. Thus, a variety of procedures have been employed during in-flight cockpit evaluation, resulting in a lack of commonality among test beds, programs, and systems. Often data from one flight test cannot be directly compared to another, leading to duplication of effort and reduced efficiency during test. The Performance Assessment and Workload Evaluation System (PAWES) offers a new way to support weapon system test and evaluation of crew station effectiveness and operational suitability.

This effort will develop and demonstrate a proof-of-concept capability for flight testing crew stations, while assuring common evaluation measures during ground, simulation, and in-flight tests. This includes steps for planning the crewstation evaluation, selecting procedures and measures, preparing briefing materials, processing data, and reporting results in a timely manner. In addition, PAWES will provide inspectable procedures for performing over 100 types of evaluations, recommend comparable measures for evaluating specific variables, and identify tools for implementation at the test facility. These computer based tools include form and report templates, a card catalog, a dictionary, an audit trail, and a notepad. PAWES will also include data analysis tools permitting a time synchronized display of digitized video, a 3-dimensional aircraft representation, and four real time data channels. This capability will allow the evaluation team to see an integrated view of the test results and aid in analyzing data.

PAWES offers a core capability to perform structured crew station evaluations using objective methods and measures. Further, PAWES will connect databases from flight tests and ground simulation. As a side benefit, PAWES will establish a link between laboratory personnel developing new human factors evaluation methods, and flight test practitioners who employ the methods, thereby facilitating the information flow between the research, development, test and evaluation communities. PAWES is a new capability for efficient crew station evaluation that will facilitate the technical communication of flight test results among engineers, researchers, and managers. A proof-of-concept PAWES will be built and tested by the end of FY94.

OPR: AL/CFHD, (513) 255-7581 [DSN 785]



Time-synchronized integrated view of flight test data to include aircraft attitude, performance, and video data.

Acceleration Protection

The advent of high performance fighter aircraft with the capability to sustain +Gz and the resultant potential for pilot G-induced loss of consciousness (G-LOC) has resulted in a concerted effort to improve G-protection. The +Gz training of high performance aircraft pilots has been beneficial and has led to significant reductions in G-LOC-related loss of aircraft and life. Training allows pilots to experience high +Gz and improve the efficiency of their anti-G-straining maneuver (AGSM) in a controlled centrifuge environment.

The AGSM is currently the most significant G-protective factor at high G (7-9 +Gz). The standard G-suit provides passive protection to about 5.5 +Gz. To maintain vision and consciousness above 5.5 +Gz, it is necessary to increase the AGSM level of effort as +Gz increase. Thus, at 9 +Gz, the AGSM effort is near maximal in many pilots. The AGSM is very fatiguing and is a limiting factor in pilot performance in the high +Gz environment.

The fatiguing aspect of the AGSM has driven us to develop new and improved G-protective equipment and techniques to reduce the need for maximal AGSM effort during high sustained +Gz. A recent improvement in G-protection is pressure breathing during G (PBG). PBG supplements the AGSM and can improve +Gz endurance during high +Gz by over 100 percent, compared to the combined protection of the standard G-suit and the AGSM. Combined Advanced Technology Enhanced Design G-Ensemble (COMBAT EDGE) incorporates PBG and is being retrofitted into high-performance aircraft at this time. An extended coverage anti-G suit called Advanced Technology Anti-G Suit (ATAGS) is also under development.

Investigation of the physiologic effect of G-protective equipment and techniques is a large portion of our research effort. It is important to understand the mechanism of +Gz protection and the margin of safety. Areas under investigation are (1) the effect of G-layoff (time away from the cockpit) on +Gz-tolerance; (2) a comparison of female/male G-tolerance/endurance during high +Gz and the influence of the menstrual cycle on female G-tolerance/endurance; (3) the physiologic interrelationship between blood pressure, intrathoracic pressure, the AGSM, PBG, and anti-G suit inflation during high levels of +Gz; and (4) man's upper limit of +Gz-tolerance as influenced by seat back angle, COMBAT EDGE, and ATAGS.

Our acceleration protection program is designed to provide the maximum +Gz protection, with a margin of safety, for pilot operational performance.

OPR: AL/CFTF, (210) 536-3521 [DSN 240]

Advanced +Gz-protection, illustrating the newly introduced pressure breathing system (COMBAT EDGE) and the advanced technology anti-G suit (ATAGS).

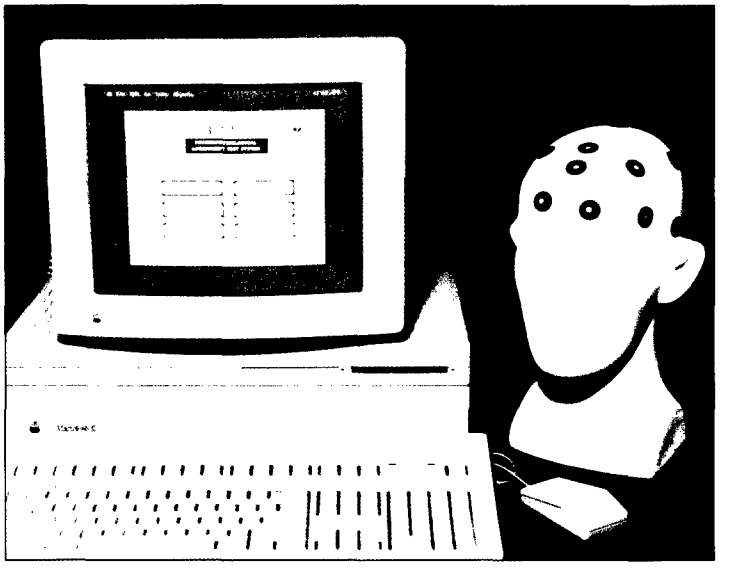
Workload Evaluation Tools

Objective measures of crewmember workload are needed for test and evaluation, design evaluation, and metric development programs. The increased complexity of modern USAF systems places higher mental workload demands upon USAF personnel. In some cases the limiting factor for new systems may be the human component. In order to design systems that can be used effectively, the mental workload placed upon the crewmembers must be measured, and systems that take human capabilities into consideration must be designed.

Traditionally, subjective measures have been used to measure operator workload, but these methods have shortcomings and need to be augmented. Measuring operator response can provide such data with heart rate, eye blinks, and brain activity acting as useful measures of cognitive activity. The Psychophysiological Assessment Test System (PATS) and the Workload Assessment Monitor (WAM) have been developed as tools to measure these signs of workload. PATS collects physiological data, stores it, reduces it, does statistical analysis, and provides many editing and analysis features. WAM provides on-line analysis of heart rate, eye blinks, and respiration. Thus, an operator's physiological state can be continuously monitored in real time and this information can be fed back to the system and evaluated by testing personnel.

Both PATS and WAM are designed to function in laboratory and simulator environments and can be used to analyze flight recorded data. Government, industry, and academic institutions have shown interest in both systems. Since they are general purpose in nature, they can fill the needs of a number of programs while meeting current USAF needs for workload measurement.

OPR: AL/CFHP, (513) 255-8748 [DSN 785]



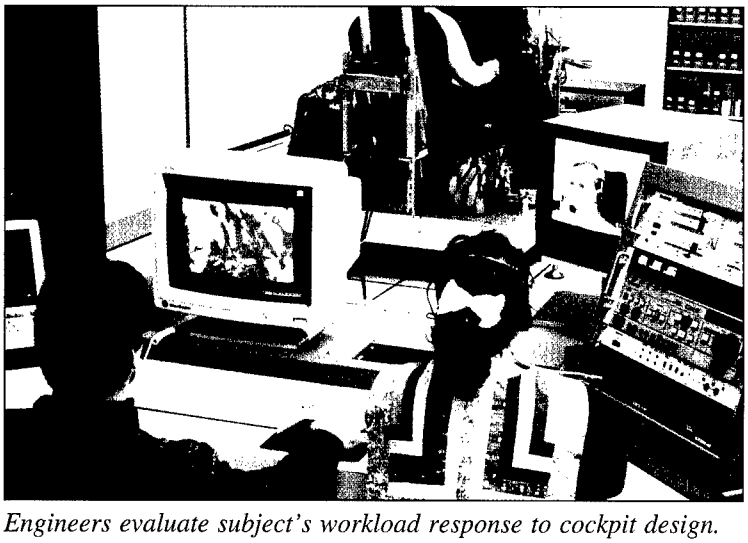
PATS collects data which can be used to reduce aircrew mental workload.

Crew-Centered Cockpit Design Project

Air operations depend on the aircrew's ability to employ all the capabilities of the weapon system. However, aircrew tasks are becoming increasingly complex and time constrained, and are often nearing the limits of the aircrew's ability to perform all required tasks. To meet this challenge, the Crew-Centered Cockpit Design (CCCD) project has formed an interdisciplinary team to develop a new cockpit design process that is centered around crew capabilities and mission effectiveness. This process is intended for use by the aerospace industry, but is adaptable for Government oversight of the system development, and for related technology development in the DOD Laboratories.

The main products of the CCCD development are its highly disciplined process for cockpit design and a complete set of support tools and technology that will help to make the process efficient. The process spans all phases of systems acquisition from concept exploration through production and deployment. It identifies and organizes each engineering design activity, while managing the flow of engineering data produced at each step. The supporting tools and technology are embodied within a Cockpit Design System (CDS), which is a self-contained design support system providing full-time support for crew-system engineering from start to finish. Included is an integrated set of cockpit analysis software, computer-aided design software for cockpit layout, database management tools for engineering data, and a real time cockpit simulator that is configurable in hardware and software for test and evaluation. The CDS computer software also affords the cockpit design team a complete and up-to-date picture of development status and work remaining, thereby serving a dual role for project management and engineering support. CCCD represents a new capability for human systems integration, correcting recognized shortcomings in the current design practice. An initial version of the CCCD design process and a full-scale functioning prototype of the CDS have been delivered and are undergoing checkout for validation and demonstration.

For the first time, the crew system can be developed using a proven process and integrated computer based tools producing a well documented, tested, and traceable design that is tied to mission requirements. Cockpit design and testing can start much earlier in the development cycle, thereby reducing cost and risk while improving operability. By designing the cockpit with crew capabilities as the central focus, CCCD can maximize the aircrew's capability to fly, fight, and win.

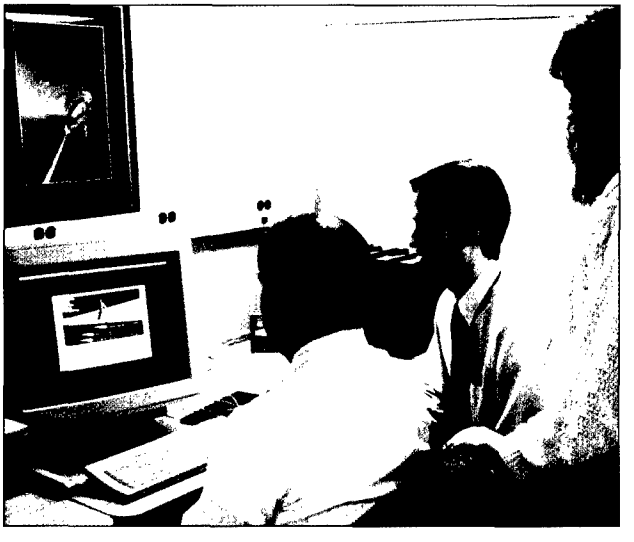


Engineers evaluate subject's workload response to cockpit design.

OPR: AL/CFHD, (513) 255-8860
[DSN 785]

Computer-Aided Systems Human Engineering: Performance Visualization System

Research and development efforts in the Design Technology Laboratory are significantly advancing the state of the art in design visualization technologies and preparing to transition those technologies into the USAF and civilian design communities. Armstrong Laboratory, leading a consortium of government organizations consisting of the Federal Aviation Administration; the Defense Technical Information Center; NATO Advisory Group for Aerospace Research and Development; the Army's Human Engineering Laboratory; the Naval Command, Control, and Surveillance Center; and the Air Force Office of Scientific Research is developing the Computer-Aided Systems Human Engineering: Performance Visualization System (CASHE:PVS).



The Computer-Aided Systems Human Engineering: Performance Visualization System (CASHE:PVS) will offer crew systems designers computerized hyperlinked access to over 1,150 entries on human perception and performance data.

CASHE:PVS version 1.0 is a CD-ROM-based hypermedia-ergonomic information base which will provide crew system designers ready and intuitive access to on-line graphical and textual human perception and performance data. Tightly coupled with this information base are sets of interactive software "test benches" which will provide designers with performance visualization capabilities to enhance their ability to analyze, explore, and apply human behavioral data to specific equipment designs. The CASHE:PVS version 1.0 will be available during the second quarter of FY94. A new contract start in the human performance and perceptual design visualization system will field test the version 1.0 software in actual design environments and will begin the development of a subsequent version for supporting collaborative design in Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) environments.

As a precursor to developing collaborative design technology, an in-depth study of actual USAF design teams has been completed. Human factors branch team members from Aeronautical Systems Center at Wright-Patterson AFB OH, were interviewed using the in-house developed knowledge engineering tools, Concept Mapper and Concept Interpreter, to explore design as currently practiced in the crew system acquisition process. This collaborative design knowledge acquisition is the beginning of a framework for the development of advanced group centered design tools.

OPR: AL/CFH, (513) 255-8805 [DSN 785]

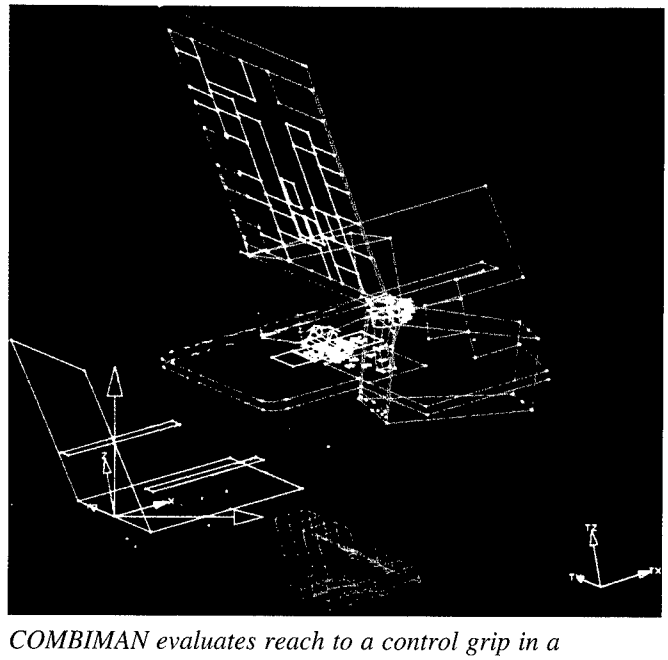
Computerized Biomechanical Man-Model

Early identification of potential design-induced operator accommodation problems is essential in order to correct a problem before mockup, fabrication, or production. To facilitate early identification of design problems, Human Systems Center's Human Engineering Division is developing Computerized Biomechanical Man-Model (COMBIMAN), a Computer-Aided Design (CAD) model of an aircraft pilot which allows the designer to perform the functions of an expert ergonomist. The designer may simulate an operator activity on the computer-generated image to determine if the activity is physically possible. Expert system software automatically creates the correct body size and proportions for male and female pilots, the encumbrance of clothing, personal protective equipment, and mobility. Expert system task analysis is available for reaching controls, visual access, and strength.

Version 9 of COMBIMAN was completed in 1992. It incorporates several databases, functional capability for 1st to 99th percentile male and female dimensions, and six flight clothing types. Automated task analyses include reach, vision, and strength analyses. The model computes strength for operating all types of vehicle controls (wheels, levers, pedals, etc.). Visibility shows the vehicle from the operator's viewpoint including controls, displays, windows, and even objects outside the vehicle. COMBIMAN's uniquely automated arm and leg reach and reach envelopes take into consideration the encumbrance of clothing and harness.

The COMBIMAN model will reduce the incidence of accommodation problems by allowing the designer to perform analyses and correct design related defects. Ultimately, not only will development engineering costs and acquisition time be reduced by doing it right the first time, but system performance will increase. COMBIMAN is interfaced directly with several popular commercial computer-aided design systems so the design itself can be used as an electronic mockup. Because the interface is direct, no file transfer or conversion is required prior to the evaluation. COMBIMAN software and analysis capabilities are now available to US businesses through the Crew System Ergonomics Information Analysis Center known as CSERIAC.

OPR: AL/CFHD, (513) 255-2558 [DSN 785]



COMBIMAN evaluates reach to a control grip in a navigator's crew station.

Advanced Dynamic Anthropomorphic Manikin (ADAM)

Armstrong Laboratory developed the Advanced Dynamic Anthropomorphic Manikin (ADAM) for use in testing escape systems and crew protection systems. Manikin development was initiated in 1985 to support the Crew Escape Technologies (CREST) advanced ejection seat program and has resulted in the fabrication of five small and five large manikins. The manikin design provides a human-like reactive load into the ejection seat and possesses realistic dynamics and kinematics during windblast, impact, vibration, and acceleration forces encountered during ejection.

ADAM was used in rocket sled tests to demonstrate "his" capability for ejection seat testing at speeds up to 700 miles per hour. ADAM was also used by Project PULL (Parachute Understanding Loads and Logistics) to develop a free fall parachute opening shock database for establishing potential injury criteria of parachute opening shock and ground impact loading.

Current emphasis is on developing a manikin-based injury assessment capability and corresponding ADAM refinements, including upgrading the ADAM data acquisition system. Composite materials have also been developed for use in manikin body segments resulting in a higher strength-to-weight ratio, more bone-like deformation properties, and more human-like inertial distribution properties than metal manikin segments. A prototype manikin leg has been fabricated with force sensors embedded directly in the composite material during production. This capability will provide researchers with information on forces transmitted through the leg segments during aircraft ejection. Further improvements include the development of an improved manikin neck structure adaptable to existing test manikins. It will provide a more human-like response than currently available manikin necks and will serve as a test and evaluation tool for head-mounted devices, protection equipment, and ejection systems.

ADAM will be a powerful test and evaluation tool for assessing ejection seat performance and crewmember protection. Its design provides for human-like reactive loading into the ejection seat and measurements on a variety of body, seat, and protection system responses. The ADAM data acquisition upgrade has been completed, and acceptance tests involving vertical and horizontal impacts were performed. Environmental tests of upgraded ADAM were completed in September 1992, and rocket sled ejection tests resumed in November 1992.

OPR: AL/CFB, (513) 255-3665 [DSN 785]

ADAM skydiving -- determination of parachute-opening shock criteria.

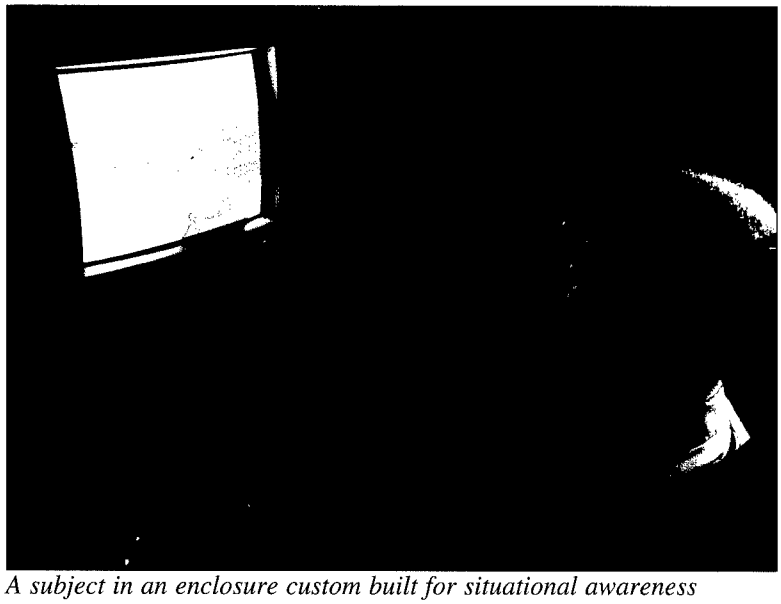
Near-Threshold Processing of Visual Stimuli

The Air Combat Command has been interested in the dynamics of pilot situational awareness (SA) since the 1980's. We now know that SA is an elusive, yet important concept, and its attainment is rooted in our human information processing capabilities. It is an ability which changes over time; pilots often claim their SA was "shut up in the map case," just out of reach, on a particular mission.

Researchers at the Armstrong Laboratory are targeting a component of SA known as "Near-Threshold Processing of Visual Stimuli," and testing two related theories. One theory is that pilots can be trained to recognize and identify objects in their environment presented for short durations (33-67 milliseconds). Pilot selectee ROTC students successfully demonstrated this training in two studies using identification of familiar playing card suit symbols. The second theory being tested is that there may be a basic ability to recognize and identify fleeting stimuli that separate top performing pilots from "average performers." Initial studies show that subjects differ widely in their performance of these tasks, but determining whether these subjects also differ in flight performance or ability to attain and maintain SA is our major goal. Neither of these theories have meaning to the USAF unless fleeting recognition skills correlate with superior SA in the cockpit. A special team, the Situational Awareness Integration Team (SAINT), was formed to coordinate Armstrong Laboratory efforts. A SAINT study using fighter pilots was completed in the fall of 1992 to try to establish the connection between near-threshold visual processing skills and operational SA.

Software has been developed to use operationally relevant symbols to test these selection and training premises. The current version uses a three-dimensional Silicon Graphics system with realistic computer-generated aircraft models and varying backgrounds. It tests pilots' abilities and gauges their performance improvement in the task. Future software will display targets in a dynamic mode, and the computer screen will emulate a moving cockpit's windscreen. If this system proves to be a valid measure for visual stimuli processing, it will be used as part of a computerized task battery for selecting pilot training candidates or in classifying students into fighter or tanker/transport/bomber tracks. Pilots might also use the system to hone this component of SA before a mission.

OPR: AL/CFTO, (210) 536-3464 [DSN 240]



A subject in an enclosure custom built for situational awareness research responds to a fleeting aircraft symbol.

Burn Prediction Model: Burn Simulator

Exposure to extreme thermal environments such as a fire, atomic flash, or aerothermal heating during emergency escape at high Mach will result in skin burns if protective measures are inadequate. BURNSIM is a computer model allowing the user to predict burn hazards. Originally written to run on minicomputers, it has been rewritten to run on more readily available personal computers (PC). Further, a module has been added to account for the insulation provided by protective clothing.

For the past two years, the Escape and Impact Protection Branch of the Crew Systems Directorate at Wright-Patterson AFB OH has been developing a PC version of BURNSIM and a clothing module for standard military clothing. In 1991, the PC version of BURNSIM was given to more than 30 users at the 2nd Annual Human Response Program Technology Transfer meeting.

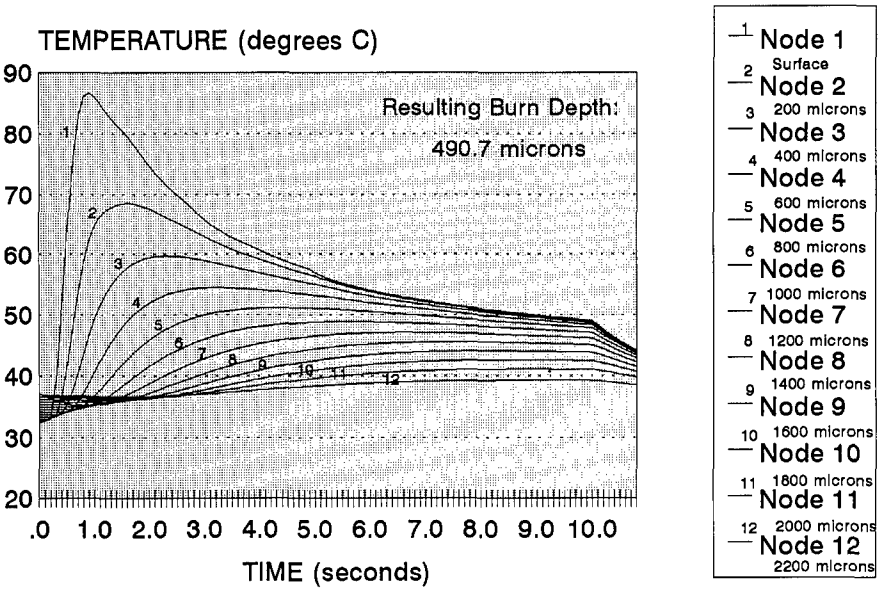
Two approaches to the clothing module have been developed. The first is an analytical solution requiring detailed knowledge of the properties and dimensions of the layers of the ensemble. The second, treats the ensemble as a lumped filter. The final clothing module will be selected, interfaced with BURNSIM, and validated over the next two years.

In addition to providing a tool for assessing the risk of burn injury for troops exposed to nuclear flash, BURNSIM has an application for conducting design studies to optimize the protective ensembles for hypervelocity vehicle crews.

Land based applications will include designing firefighters' protective clothing, foundry workers' clothing, and burn risk assessment associated with live fire studies of military systems.

Space based operations will also require a burn hazard assessment of injury causes.

OPR: AL/CFB, (513) 255-3931 [DSN 785]



Output of BURNSIM model predicts severity of skin burn.

Aircraft Windscreen Field Measurement Device: Haze-o-Meter II

The majority of military aircraft windscreens are made out of tough plastic to minimize the possibility of the windscreen shattering. However, the switch from glass to plastic has caused several phenomena which can impact the optical quality of the transparency. One of these phenomena is haze, which is caused by the scattering of light from materials (interlayers) within the windscreen and from tiny scratches on the surface of the relatively soft plastic.

At the request of the Windscreen System Program Office, a field usable measurement device has been developed to determine both the severity of haze (without removing the windscreen from the aircraft) and the correct time to repair the windscreen because of haze. Since haze scatters light backward (toward the light source) as well as forward, a single device can house both the test light source and the light detection system necessary to make the measurement. Furthermore, the device can be calibrated in such a way that the haze readings are nearly identical with the measurements obtained by removing the windscreen and testing it in the laboratory. Armstrong Laboratory researchers have patented the device called Haze-o-Meter II.

Haze-o-Meter II being used to measure F-15 canopy during device field test at Eglin AFB FL.

The Haze-o-Meter II was field tested in the summer of 1992 at Eglin AFB FL on an F-15 windscreen which had been in service for about 18 months. It performed well and is undergoing further improvement to make it easily usable by maintenance personnel.

OPR: AL/CFHV, (513) 255-8816 [DSN 785]

Spatial Disorientation Countermeasures

Spatial disorientation (SD) remains one of the leading causes of fatal aircraft accidents in the USAF. The improved capability of modern weapon systems to operate at night and in other conditions of degraded visibility creates situations especially conducive to SD; and increasing reliance on low-level maneuvering in combat tactics reduces the margin for error when SD does occur. Solutions to the SD problem are being sought in a three-pronged research and development attack: (1) improve our understanding of the mechanisms of spatial orientation and disorientation, (2) develop training methods that help pilots either resist or cope with SD, and (3) develop flight instrument displays that improve pilots' ability to maintain accurate spatial orientation.

The Visual Orientation Laboratory generated strong evidence supporting a new theory of the three-dimensional nature of visual attention--visual research and object recognition is most efficient in the upper right quadrant of the visual field. Additional work showing different effects of wide- and narrow-field-of-view background scenes on postural stability and manual control was completed. Both of these studies helped develop important concepts for efficient presentation of visual information on flight instrument displays. Research quantifying the "G-excess" form of SD was completed on the Dynamic Environment Simulator. Illusory vehicle tilts of 10 degrees were demonstrated when subjects' heads were tilted during exposure to G-levels up to +4 Gz. This finding helps explain why pilots tend to overbank their aircraft and inadvertently descend while looking out of the cockpit during sustained turns.

The Advanced Spatial Disorientation Demonstrator (ASDD) was delivered to the Armstrong Laboratory and the USAF School of Aerospace Medicine. This device will demonstrate to pilot trainees both visual and vestibular forms of SD in a special purpose flight simulator. Training methods for use with the ASDD will be developed and transitioned to Air Education and Training Command and Air Combat Command.

Flight instrument display research continued in two areas: head-up display (HUD) symbology and acoustic orientation. After evaluating competing HUD primary flight symbology elements, researchers provided the Joint Cockpit Office with optimally performing elements of a proposed USAF standard HUD symbology suite. Results of earlier flight-testing of a prototype Acoustic Orientation Instrument were analyzed, and laboratory refinement of candidate acoustic signals for airspeed, vertical velocity, and bank angle was accomplished.

SD Countermeasures research will improve the operational effectiveness of our weapon systems and reduce the drain on USAF resources resulting from SD-related aircraft mishaps.

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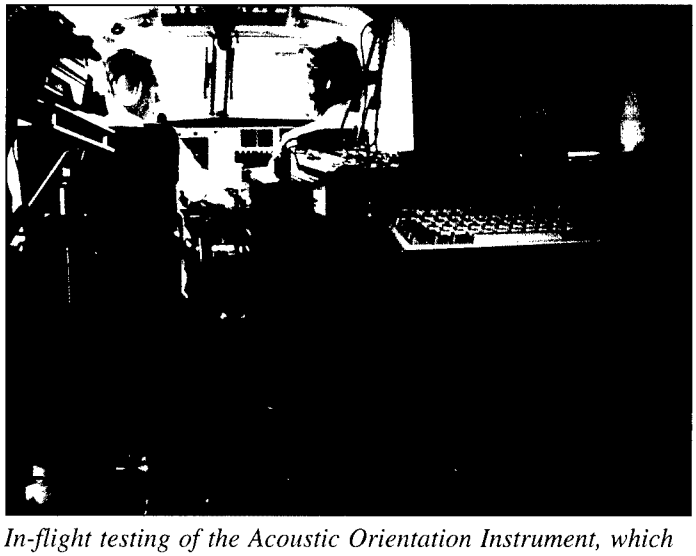

In-flight testing of the Acoustic Orientation Instrument, which provides an auditory display of bank angle, vertical velocity, and airspeed.

Personal Computer Software System for Crewmember Ejection and Crash Analysis

The Articulated Total Body (ATB) model is a computer simulation program developed by the Armstrong Laboratory (AL) for predicting human body dynamics during aircraft ejection, crashes, and other hazardous events. It is based on the Crash Victim Simulator developed by the National Highway Traffic Safety Administration (NHTSA) during the early 1970's. Its ability to predict internal and external responses of the human body, manikins, seats, and other structures, makes the ATB model broadly applicable in the automobile, aerospace, and other transportation communities. Recently, under a Small Business Innovation Research (SBIR) effort, the model has been installed on microcomputers, easing accessibility to a wider variety of users.

The ATB model has been used to determine the safety of proposed structures in the aircraft cockpit before prototypes were built or costly tests conducted. It has also been used to provide data that cannot be measured during a test, such as forces within the body, and to supplement test data through the ability to vary the parameters of the simulations.

The ATB model is used to test theories on the events during an accident and the cause of injury. It is also used to test the effects of design changes on safety before prototypes are built and costly tests are conducted. The model is also widely used in the civilian sector for improving consumer safety in the automobile industry. It is ideally suited for the commercial sector because it is applicable to many dynamic systems and can be used on different computer systems. Individuals investigating automobile accidents, developing restraint systems, studying human motion in any dynamic environment or interested in other dynamic systems can use the ATB model for their analysis.

The Phase II Small Business Innovative Research contract to install the ATB model on a microcomputer and develop a complete software package for improving its user-friendliness ended in October 1992. This package, named DYNAMAN, includes a user-friendly preprocessor for developing the simulation database, the ATB model, and a postprocessor for plotting the simulated body motion and graphing time history results. DYNAMAN operates on microcomputers running under DOS and on Silicon Graphics workstations.

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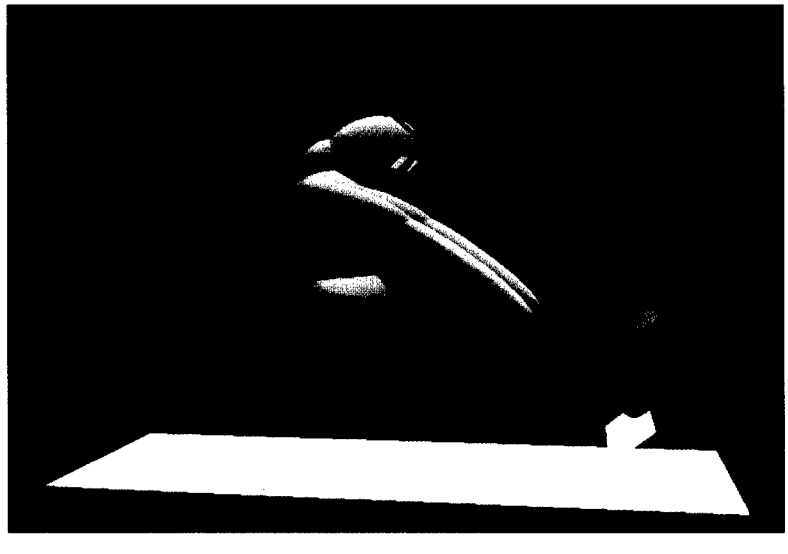

ATB simulation of a crewmember during a cargo plane crash landing, studying head impact with head-up display.

Live Fire Testing and Human Vulnerability Assessment Methodology

In 1986 the United States Congress passed a law requiring all major weapon systems be tested for vulnerability and lethality. The tests were to place special emphasis on personnel casualties. This statute led to development of the Joint Live Fire Test program. Armstrong Laboratory's program assesses potential threats that may incapacitate aircraft personnel. It assesses the impact on aircrew of penetrating injuries from fragments, burn injuries from fires and explosions, toxicological effects from combustion gases, and hearing loss and organ damage from blast overpressures. Measurements are taken during realistic combat environment simulations which are produced in a highly sophisticated firing range with state-of-the-art instrumentation. A unique product of this research is a fragment capture manikin called Aerospace Incapacitation Response Manikin (AIRMAN), a spin-off technology from the NASA shuttle program.

Live-fire tests simulate controlled battlefield conditions, so the researcher can obtain accurate descriptions of the environment behind defeated armor on weapon systems. Information obtained from these tests helps predict the pilots' ability to successfully complete their missions. To collect data needed to determine the environment a pilot is exposed to, a variety of heat, pressure, and gas sensors are placed on the AIRMAN manikin and the manikin is placed in a full-scale aircraft crew station. A specially designed gun fires a predetermined size round into the crew station, and researchers analyze data from the sensors. Fragments that would hit the pilot are captured by the manikin. These data determine the injury a real human might receive, and conclusions are drawn on the pilot's ability to complete the mission.

Information obtained from live fire tests will establish standards for the design, development, and acquisition of future aircraft weapon systems and aircrew personal protective equipment. This information will provide understanding of combat injuries aircrew may receive from future threats. The live-fire test data can also be used to develop realistic computer simulations for training.

The F-15 Live Fire Test was completed in May 1991 and provided valuable information on human vulnerability which is the cornerstone of our research. The biological assessment of AIRMAN F-15 Live Fire Test data is being evaluated by the US Army Ballistic Research Lab using their "Computerman" wound simulator. To improve upon AIRMAN measurement techniques, a program to develop a computer-aided measurements system was initiated. This system will provide accurate, consistent, and user friendly analysis of AIRMAN data.

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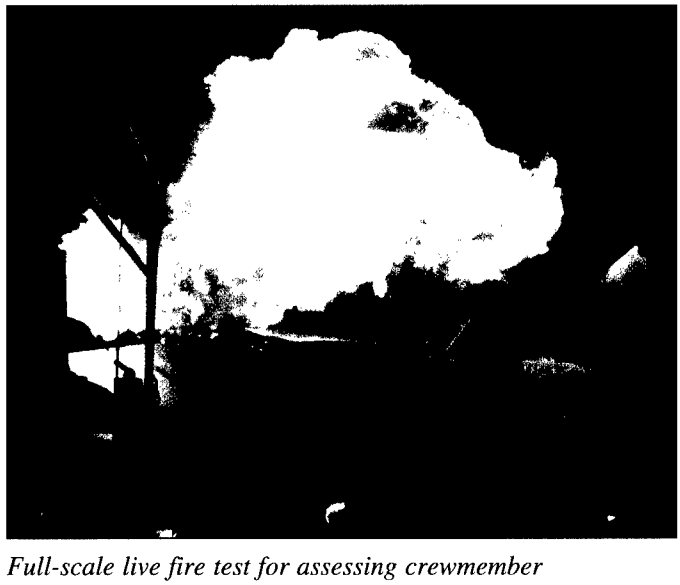

Full-scale live fire test for assessing crewmember vulnerability.

Hypersonic Flight Crew Escape

The Hypersonic Flight Crew Escape effort will provide the design criteria and evaluation techniques necessary to increase crew survivability during emergency egress from hypervelocity flight vehicles. Initial efforts will define ejection seat performance envelope limits due to aerodynamic and thermal loads acting on the crewmember, and build human systems technology required to develop advanced enclosed escape systems for crew protection at hypervelocity speeds. Existing test data will be analyzed to develop methodology for balancing the inertial and aerodynamic forces acting on the human body during emergency escape and to determine the burn injury potential from transient thermal exposure. These analyses will help to define the Mach limit of ejection seats and provide analytical methods and criteria required to maximize performance and develop or modify personnel protection systems. Advanced development programs will investigate the heat transfer characteristics of proposed pressure suit materials. Subsequent efforts will focus on human systems' issues associated with hypervelocity escape system concepts using separable forebodies. These issues involve developing human tolerance criteria for transient multi axial and long duration oscillatory accelerations.

A study contract was awarded to McDonnell Douglas Missile Systems in 1991. This study provided the design concepts, analytical tools, and evaluation methods that will be used in the development of crew escape systems for the X-30 and subsequent generations of manned transatmospheric vehicles. The escape simulations conducted have highlighted the need to advance specific key aeromedical technologies to enable the successful development of hypervelocity escape systems. The results of this concept study will be applied to the development of future hypersonic aerospace vehicles.

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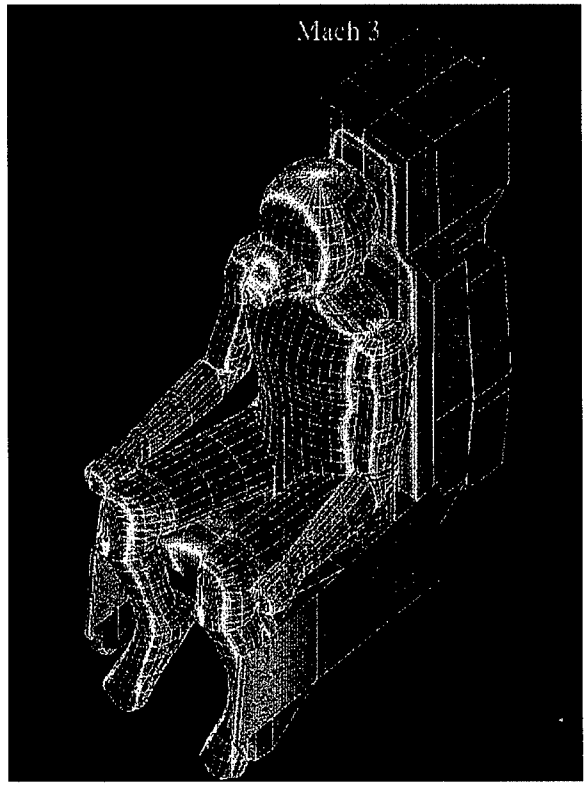

Predicted Pressure Coefficient on the Crew Escape Technology Seat, Mach 3.

Helmet Visual Display System

Unique Helmet-Mounted Displays (HMD) are being developed to meet specific user needs. Cooperative efforts with the US Army, Rome Laboratory, and Wright Laboratory have maintained direct user interface in our helmet display optics development activities. One such user-specific device under development is the bi-catadioptric helmet-mounted display (BI-CAT HMD) system.

The BI-CAT is based on bi-catadioptric lenses and provides a color-corrected, 50-degree, fully overlapped, binocular field of view with a very large 19-millimeter exit pupil for ease of use. The display mounts to a HGU-56 helmet and includes interpupillary adjustment. To allow for the future, it incorporates newly used tangent (theta) optics mapping to permit its direct use with advanced miniature LCD color image sources as they become available. Development of a new miniature cathode ray tube with a 23-millimeter active format area made it possible to achieve excellent performance.

Two BI-CAT HMD systems will be delivered to the Army for testing in a Blackhawk helicopter as part of a joint NASA/ US Army flight test. Rome Laboratory and Wright Laboratory will also take delivery of systems for use in their simulation work. Other advanced HMD optical systems are in preliminary design to meet specific user requirements and to feed into the Helmet-Mounted Systems Technology Advanced Development Program Office efforts.

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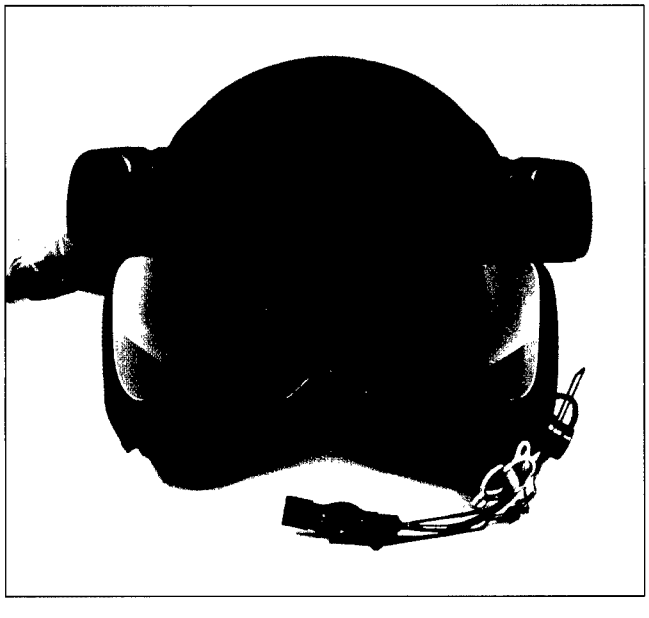
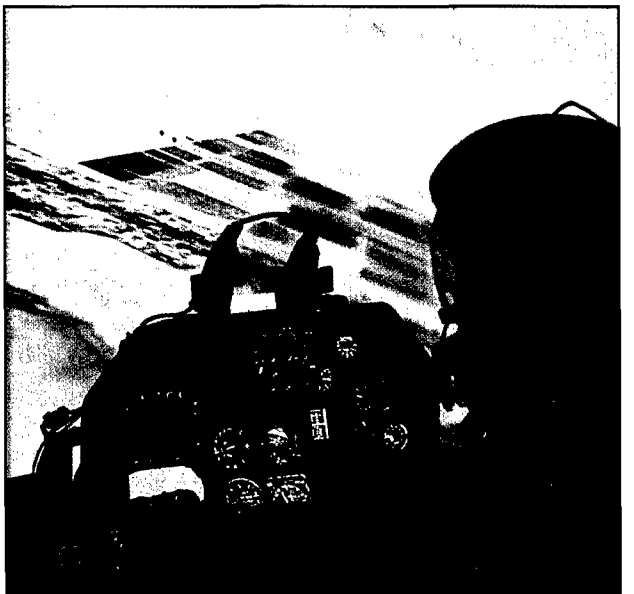


Helmet-Mounted Displays such as "BI-CAT" must be tailored for specific user needs.

Human Resources



This Human Systems Center product area accomplishes research and develops, fields, and supports unique Manpower, Personnel, and Training technology and systems.

Weapon System Optimization Model

The USAF weapon system acquisition process requires weapon system life cycle cost and performance criteria to evaluate the emerging weapon system during design and development. Manpower, personnel, and training (MPT) factors must also be considered at the design phase. Major command (MAJCOM) planning shops and MPT Planning Team members need a model to consider tradeoffs among weapon system characteristics, maintenance, and logistic concepts; MPT factors; and performance/cost parameters. The Weapon System Optimization Model (SYSMOD) will integrate MPT issues into the early weapon system design process.

Front-end analysis for SYSMOD development was completed in 1991, resulting in a conceptual research and development plan and a demonstration model for user feedback. Input/output variables were identified and system specifications developed. The prototype SYSMOD will be a personal computer based user-friendly information management system needing minimal user knowledge to operate. SYSMOD will take into account not only MPT requirements, but also organizational structure, maintenance, and operational concepts, and sortie requirements. Follow-on efforts will include necessary model refinements to interface SYSMOD with the MPT Decision Support System, which will provide MPT analysts a tool for use in post-Milestone I weapon system acquisition analysis.

SYSMOD will provide MPT Planning Team members and MAJCOM planning personnel with the integrated tool they need to develop early MPT criteria for weapon system design. It will provide concrete data for cost vs performance tradeoffs to optimize weapon system operation and maintenance support.

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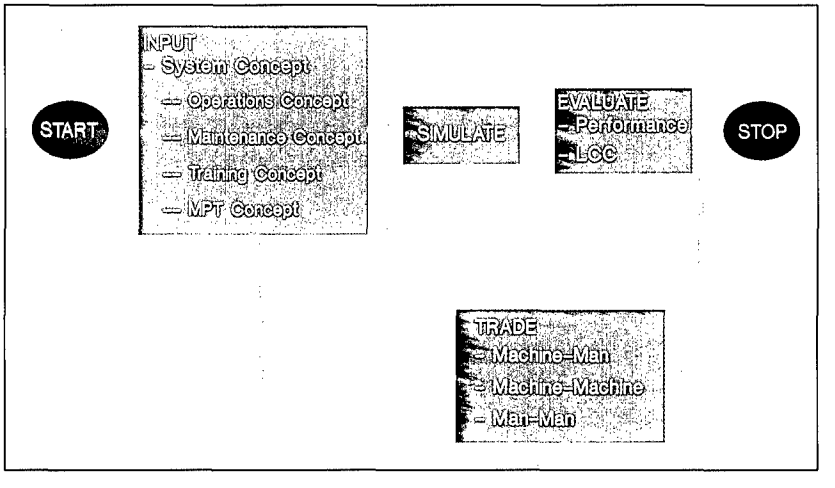


SYSMOD integrates MPT issues early in the design process

Learning Abilities Measurement Program

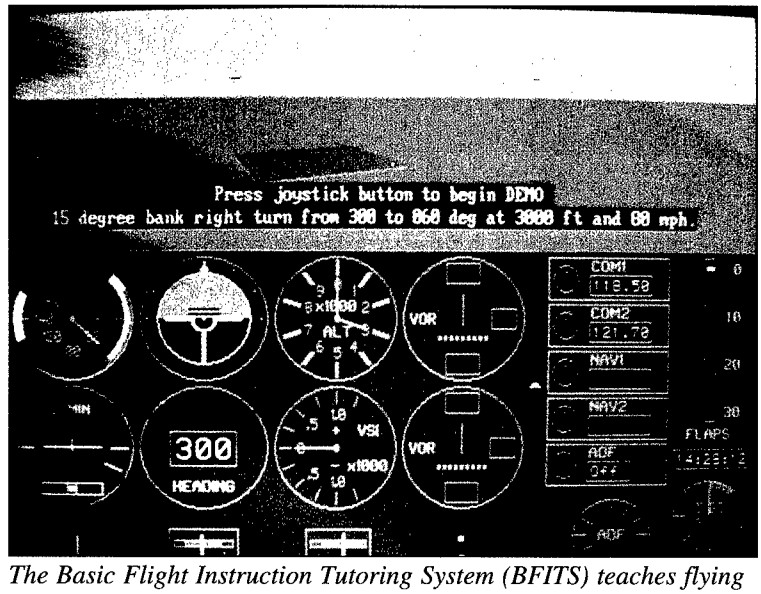
USAF personnel work in highly technical environments. The challenge is to identify individuals most likely to succeed in these environments. Recent developments in personnel assessment technology promise to enhance the selection and training of our personnel. The Learning Abilities Measurement Program (LAMP) is a basic research effort to identify learning abilities using computer based aptitude assessment technology. Information processing tests delivered on microcomputers measure abilities not captured by traditional written tests and bring increased flexibility, comprehensiveness, and utility to personnel selection and training.

LAMP scientists developed and refined the Cognitive Abilities Measurement (CAM) battery. The CAM measures such abilities as processing speed and capacity, and when used in conjunction with the Armed Services Vocational Aptitude Battery will improve the ability to predict training success. We validated the improved prediction capability of CAM in the areas of computer programming, basic electricity, and flight engineering.

Presently LAMP scientists are investigating new abilities such as speed-distance estimation, multi-model (auditory versus visual), and perceptual motor processing. We will relate these abilities to the acquisition of basic flying skills using the Basic Flight Instruction Tutoring System which yields a detailed quantitative record of learning performance.

LAMP scientists also collaborated with aircrew selection and classification experts to develop a Situational Awareness Aptitude Battery. The goal is to identify pilots who develop the highest degree of situational awareness in flying combat missions. In the near future, scientists will develop performance assessment batteries to evaluate the effects of unusual environments (e.g., space), disruptive, stressful environments (e.g., cockpit, control tower), and medical conditions (e.g., drugged state) on thinking, learning, and problem solving ability.

LAMP results indicate that assessment technology can improve the current selection and classification system. These improvements will reduce training costs and enhance training procedures and performance measures.



The Basic Flight Instruction Tutoring System (BFITS) teaches flying skills and records performance data.

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Manpower, Personnel and Training Decision Support System

Manpower, personnel, and training (MPT) issues are integral to weapon system operation and performance, and account for about half of the life cycle cost. At this time there is no effective process to account for MPT issues during weapon system design and acquisition. The MPT Decision Support System (DSS) will provide an integrated software system to permit up-front estimation of MPT requirements during weapon system development. It will also enable tradeoff analyses and allow validation that emerging designs meet MPT constraints. In addition, it will provide planners with information needed to set up personnel acquisition and training pipelines.

The MPT DSS builds on technology developed for the USAF Integrated Manpower, Personnel, and Comprehensive Training and Safety, known as IMPACTS, program. Databases have been developed and integrated, and procedures developed for database linkage, tradeoff analyses, and automated instructional system development. The MPT DSS will be complete in 1996.

Integrating MPT tradeoffs early in the weapon systems acquisition will reduce cost, improve weapon system supportability, and maximize combat readiness. MPT DSS will ensure the USAF meets operational requirements despite reduced MPT resources and shorten the time between system delivery and full operational capability.

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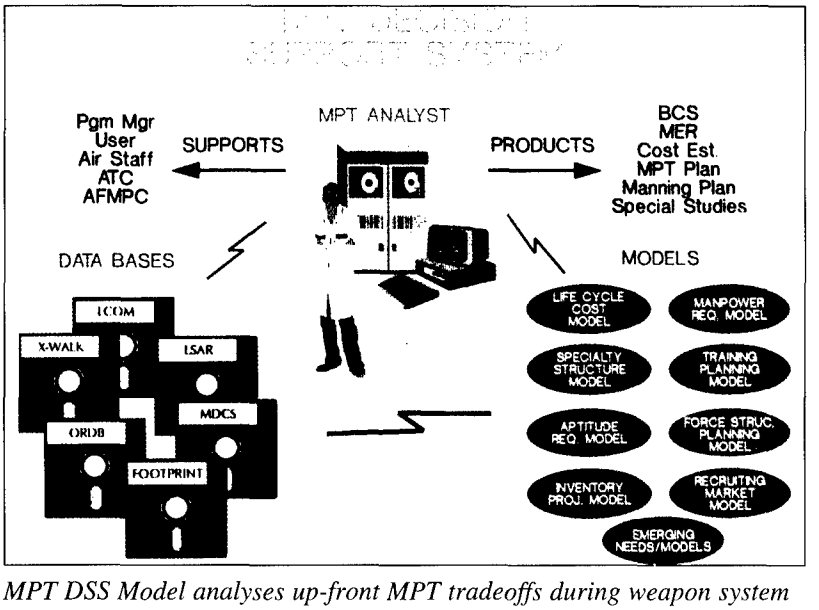

MPT DSS Model analyses up-front MPT tradeoffs during weapon system development.

Productivity Capacity Project

USAF enlistment standards are continuously evaluated and raised or lowered, as necessary, to ensure recruits have the aptitude to successfully complete technical training. With the force size shrinking and competition for high-quality personnel increasing, Congress and DOD are scrutinizing standards closely to assure adequate linkage not only to training outcomes, but also to later actual job performance.

Exploration of alternate measures of job performance to serve as criteria has become a priority research topic. Accurate and fair measures are essential. Further, performance measures must be "user friendly" to enable operational managers to specify their minimum job requirements precisely and easily.

Productive capacity is one of the innovative scales being studied. It reflects the amount of work per unit of time an individual could produce, relative to the most productive member of that USAF specialty. Hands-on tests of job tasks are set up in the workplace, then actual times are recorded for enlisted personnel to satisfactorily complete the tasks. Supervisors are also participating to determine if they can give accurate estimates of the productive capacity of their employees. A major research interest is whether the less costly supervisor estimate can be substituted for the labor-intensive hands-on test.

During the initial field tryout, researchers collected data on 600 airmen in four Air Force Specialties: Aircrew Life Support (122XO), Aerospace Ground Equipment (454X1), Avionics Communication and Navigation (455X2), and Personnel (732X0). Preliminary results were encouraging, and productive capacity measurement in additional jobs is underway.

The most immediate and important application of productive capacity research focuses on setting enlistment standards for optimal selection and classification of USAF personnel. The measures also have potential value in evaluating the impact of personnel policies, such as the force structure and training practices on job performance.

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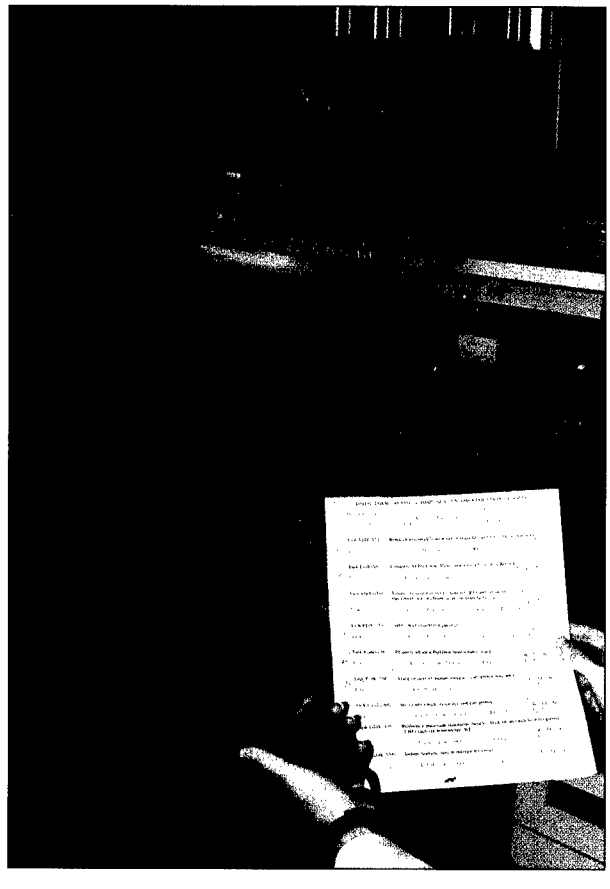

An avionics specialist is timed and evaluated as he performs a task in the hands-on performance test.

Pilot Candidate Selection Method

The identification of candidates most likely to succeed as USAF pilots is a key USAF goal. The maneuverability and complexity of USAF aircraft demand exceptional physical condition, psychomotor coordination, and cognitive abilities. The Pilot Candidate Selection Method (PCSM) is a system which will combine computer based Basic Attributes Test (BAT) scores with more conventional paper/pencil tests to obtain a prediction of candidate performance in Undergraduate Pilot Training (UPT). UPT attrition rates have been well above 20 percent over the last several years. PCSM will fill the existing requirement to improve the current selection procedures.

The BAT battery consists of six computerized tests that assess individual differences in psychomotor coordination, information processing ability, and personality. The BAT also includes a short biographical section which records the subject's age, previous flying experience, and other data.

Related efforts include a project to tie situational awareness in fighter pilots to computer administered tests, and a test battery developed in collaboration with the Euro-NATO Aircrew Selection Working Group. European selectees for the Euro-NATO Joint Jet Pilot Training (ENJJPT) program at Sheppard AFB will be assessed using the BAT and tracked through the program.

BAT stations were developed by the Human Systems Program Office and deployed at over 100 training sites throughout the USAF. A test processing station was also installed at Air Force Military Personnel Center to automatically receive and process BAT scores from the USAF training sites.

Payoffs from using PCSM include high-quality pilot candidates, reduced attrition, decreased training costs, optimal assignment, increased job satisfaction, and improved retention.

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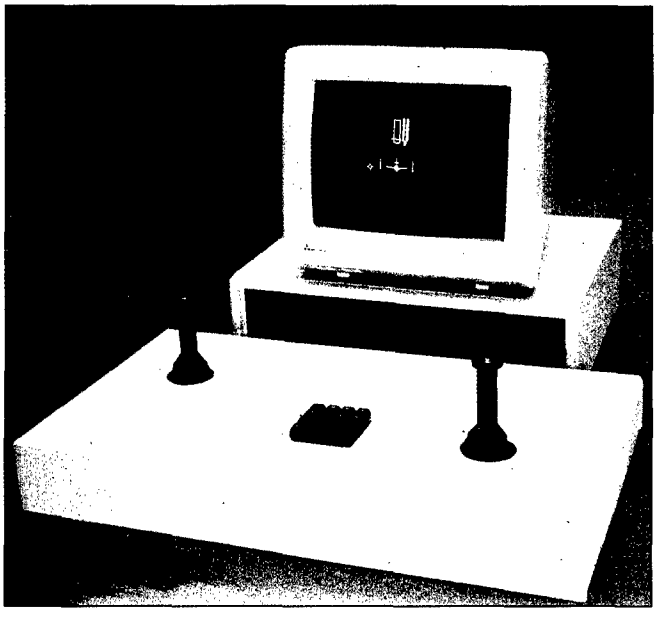

PCSM system evaluates aptitude of undergraduate pilot candidates.

Job Design System

The military has entered a period of rapidly shrinking resources. The USAF needs to broaden many current job boundaries, create "generalists" rather than "specialists," and consolidate job categories into a smaller number of specialties. Complex rearrangements of duties are needed in certain job areas because of advancing technologies and new deployment concepts. Most research in the past has been directed toward matching people to existing jobs or specialties. The current research is aimed at defining the requirements of new or hypothetical specialties that might result from an extensive classification restructure.

A Job Design System is being developed to address these problems. Job requirement technologies being researched include procedures for identifying, describing, and measuring the characteristics of people and jobs. Examples include the physical demands and learning difficulty of tasks and jobs; the knowledge, skills, and attributes needed for successful job performance; and the aptitudes and technical training required for entering specialties.

Technologies that address the transferability of skills are being developed and include research of methods for estimating retraining times, job learning difficulty, and ease of movement for personnel changing from one job to another. Restructuring methods include engineering approaches to job design based on time studies; workflow analysis, and various efficiency measures; participative approaches involving employee working groups and quality circles; and modeling approaches that simulate the effects of a given job structure.

The Job Design System will be applicable to other services and agencies within the DOD and to other agencies that manage a large number of people across multiple job classifications. Under the Project TAPSTEM initiative, the Army Research Institute is sending research scientists to work in Armstrong Laboratory Human Resources Directorate, Job Structure Branch to address related issues.

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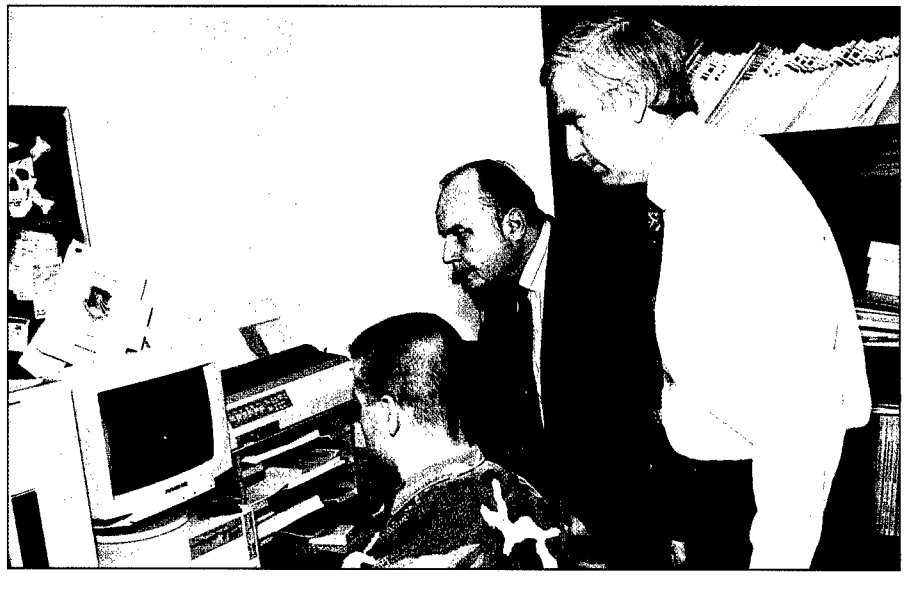

Scientists are working to increase the speed with which occupational analysis data can be collected and analyzed.

The Automated Personnel Testing Program

In order to guarantee that the best qualified individuals are selected by the USAF, it is essential that the most current approaches to identifying learning abilities and sophisticated measurement be used for selection and classification. In the recent past, significant advances have occurred in the psychological theory of the underlying abilities related to training and job performance and in the technology available to measure these abilities.

The Automated Personnel Testing project (APT) is a recent initiative designed to evaluate the utility of computerized selection and classification instruments. This will be accomplished by examining the validity of the tests in predicting performance in technical training. The first tests to be examined are cognitive ones developed in the Learning Abilities Measurement Project (LAMP). Unlike the traditional selection and classification test currently used by the USAF, this new battery of tests is based on an information processing approach to learning. Here, more basic factors related to learning such as speed of processing and working and long-term memory capacity are measured rather than the more traditional measures of aptitude such as verbal and quantitative abilities.

The second purpose of APT is to expand the criterion space beyond that currently used for validation. At present, the measure used to validate USAF selection and classification tests is technical school final grade. Although this is a good measure, it captures only a part of a person's knowledge about the job. New criteria will be developed using training outcome measures currently gathered in technical school. Broader criteria will allow a more accurate estimation of the validity of the tests.

Concurrent with the primary work, APT scientists will be involved in research on computer testing issues. Among the issues to be addressed are the contribution of previous computer experience to computer test performance. Investigation of such issues will enhance the validity and the fairness of the tests.

The APT program will benefit the USAF by identifying tests which provide greater selection validity and more classification efficacy than do the tests currently used.

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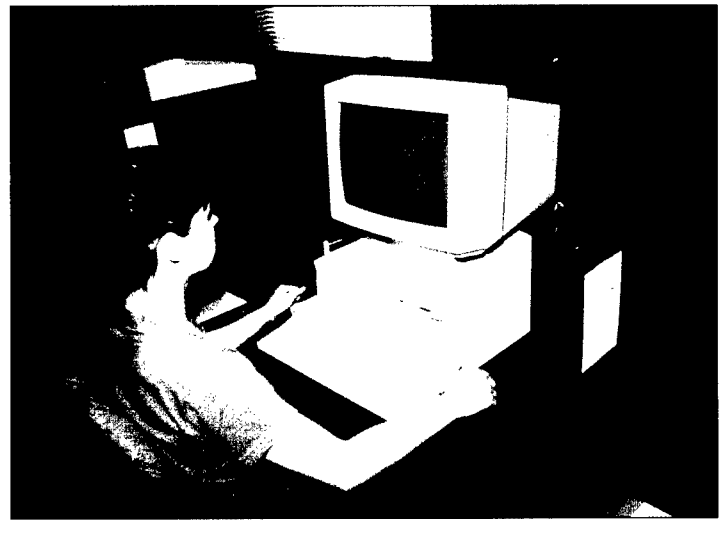

Recruit being evaluated with computerized test battery.

Simulation Utility Management System

The future outlook for the DOD is a decline in total budgeted dollars resulting in overall enlisted force reductions. To remain operationally prepared, the USAF must be concerned with optimal force structures and experience mixes within and across career fields that maintain mission readiness while minimizing overall costs of training and maintenance of the enlisted force. Conceptually, tradeoffs should be possible between experience, productivity, and force size; i.e., a more experienced force may need smaller numbers of personnel to maintain a desired level of productivity.

The Simulation Utility Management System (SUMS) model provides manpower managers and policymakers with a tool to analyze the effect of manpower decisions and personnel policy on specific enlisted career fields or overall force structures. Given an initial force structure and accession pool, SUMS simulates a policy decision (e.g., 10 percent force reduction in the third year) and evaluates the overall force productivity changes based on that decision. In addition, SUMS provides the end strength, accessions, and overages/shortages for each year of the simulated time period. SUMS can also analyze current force structures and assist in the determination of optimal force structures given a desired future end strength in terms of aptitude and experience within and across USAF specialties.

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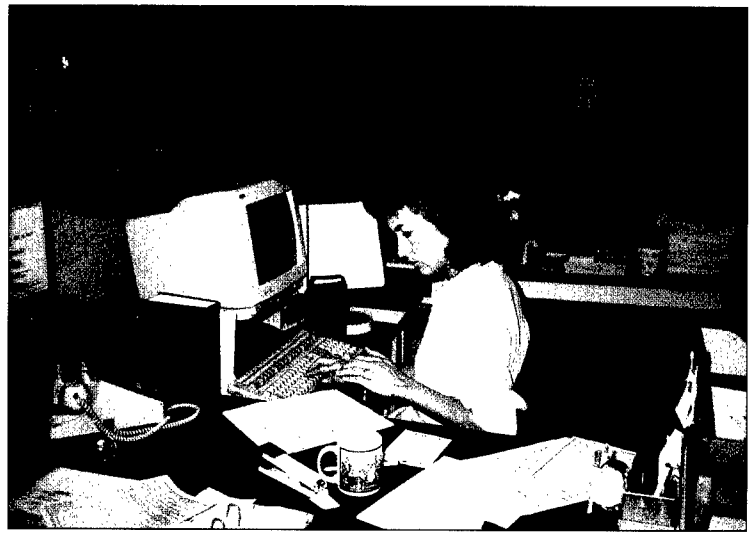

SUMS allows personnel managers to simulate the effects of force structure policy changes.

Isoperformance Methodology as a Framework for Human Systems Integration: SBIR Study

In recent years weapons systems and products have become more advanced as technology advances, and logistics requirements have increased in kind. Weapons development contractors are faced with a dilemma because the costs related to system/product acquisition and support are increasing at alarming rates, while the climate of decreasing military budgets results in less money. In view of these trends, one of the greatest challenges facing the Defense Systems Acquisition process today is to meet the need for more effective and efficient use of our resources. The national push to increase productivity in an environment of tight resources has placed emphasis on all phases of the weapon systems' life cycle. As a result, one primary requirement for weapon systems developers is to analyze the logistics, human factors, and manpower, personnel, training, and safety implications of alternative approaches as part of the weapon systems' design process in order to maximize human systems' effectiveness.

The Human Systems Center is conducting a Phase I Small Business Innovation Research (SBIR) study to assess the applicability of Isoperformance Methodology as a Framework for Human Systems Integration (HSI) issues in the design and acquisition of weapons systems. The study has several advantages: (1) it is a cost-effectiveness analysis and as such directly addresses the need not only to have HSI solutions, but also to have affordable solutions; (2) it provides authentic tradeoff functions; and (3) isoperformance is not an isolated approach but could be integrated with other HSI approaches. Phase I will result in the draft of a script that will guide the user through the design process using a question-and-answer approach with supplemental illustrative and informative materials. This will provide the basis for a computer program designed to run on USAF standard microcomputers.

The benefits anticipated from this study include integration of human factors issues and how to develop technically sound, meaningful tradeoff functions into the design process. A successful effort would do much to forward the current state of these integration methodologies. In particular, study results are expected to contribute innovative techniques to Armstrong Laboratory efforts such as the Manpower, Personnel, and Training Decision Support System.

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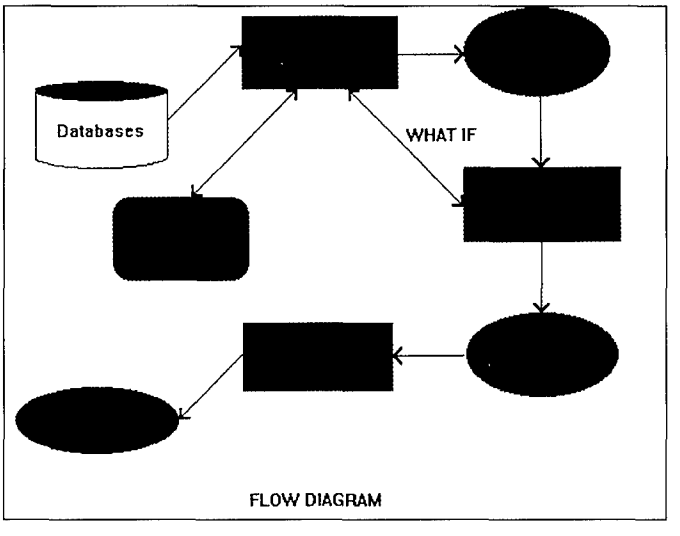


FLOW DIAGRAM

Cycle Ergometry Fitness Test

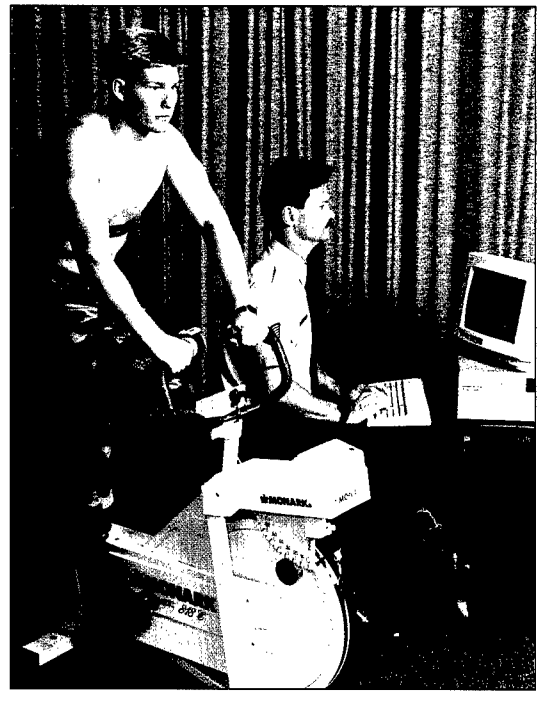
USAF interest in the cycle ergometry method for determining individual physical fitness began in the early 1980's when field studies showed that an alarming number of USAF ground crew were physically incapable of performing strenuous operational tasks under simulated chemical/biological warfare conditions. The fact that all of these "failures" had successfully completed the annual USAF fitness test (i.e., 1.5-mile run or 3-mile walk) was evidence that these methods of measuring fitness were not identifying problems of physical unpreparedness. However, the Armstrong Laboratory demonstrated that a safe and relatively simple estimate of cardiovascular fitness from heart rate response to submaximal exercise on a cycle ergometer could accurately predict performance in a variety of tasks requiring strength and stamina.

The cycle ergometer test is based on the physiological principle that heart rate increases directly with increases in work intensity. Exhaustion occurs when an individual's heart rate has reached its maximum, which is estimated as being 220 minus age. Thus, for a given level of work, the higher the heart rate, the greater the stress and the closer an individual is to his or her limit of performance.

The precision instrument used in the cycle ergometry test allows one to accurately measure exercise heart rate response to a precise workload. People with high heart rates at low workloads are significantly less fit than those with low heart rates at high workloads. Fitness scores represent cardiovascular fitness, and standards are based on (1) population averages that are age related, and (2) levels required for specific physical tasks.

The cycle ergometer program was adopted as mandatory for all USAF firefighters in March 1989. At about the same time, the program was selected for evaluation in a model health promotion program at Carswell AFB TX; it was adopted as the fitness testing method for all students entering the Air War College (Maxwell AFB AL); and it was being requested for implementation in a number of Air Force Health Promotion programs in all commands. In May 1991, this program was implemented on a trial basis at HQ Air Force Systems Command; it was subsequently adopted as the new fitness-testing program and implemented command-wide in February 1992. During this same period, General McPeak, Air Force Chief of Staff, directed the USAF Surgeon General to take responsibility for implementing this cycle ergometry fitness testing program for all USAF personnel, thus replacing the 1.5-mile run/3-mile walk test.

OPR: AL/CFTO, (210) 536-3464 [DSN 240]



New USAF Physical Fitness Test: Computer-guided cycle ergometry for assessing cardiovascular fitness.

Air Force Uniforms

The USAF is undergoing dramatic changes in composition and structure in the nineties and the uniform is changing right along with it. This is the first major design change to the entire service dress uniform since its inception in the days of General "Hap" Arnold. USAF men and women have completed testing the new uniform design. The wear test was conducted primarily in three areas of the country with approximately 800 participants. The wear test lasted from May to November 1992, and questionnaire collection and analysis were completed in January 1993.

Various changes have been introduced to the new uniform, including a more streamlined design. On the service dress coat, simulated welt and flap pockets have replaced the patch pockets. The "US" on the collar and the name tags have been eliminated. New rank designations and buttons were also tested. Two new styles of the skirt were tested for women. Both styles were designed to fit a wide range of body types while allowing more room for walking. In a move toward using more natural fabrics and commercially available components, the three fabrics tested were polyester/wool blends. The fabric selected for both officers and enlisted was the 55 percent polyester/45 percent wool serge weave. The styles for both men and women are similar with a three-button front, greater ease and a more comfortable fit.

The Human Systems Center's Air Force Clothing Division also develops all other new uniform items for the USAF such as the women's maternity jumper, tuck-in blouse, slacks, and (for both men and women) a new polyester/wool shirt fabric. Furthermore, we modify existing uniform items to improve comfort, wear, and serviceability to the members of the USAF.

The end result is a simple yet distinctive appearance. The design changes, new fabric, and wear testing contribute in producing a USAF uniform that members can wear proudly to reflect their profession.

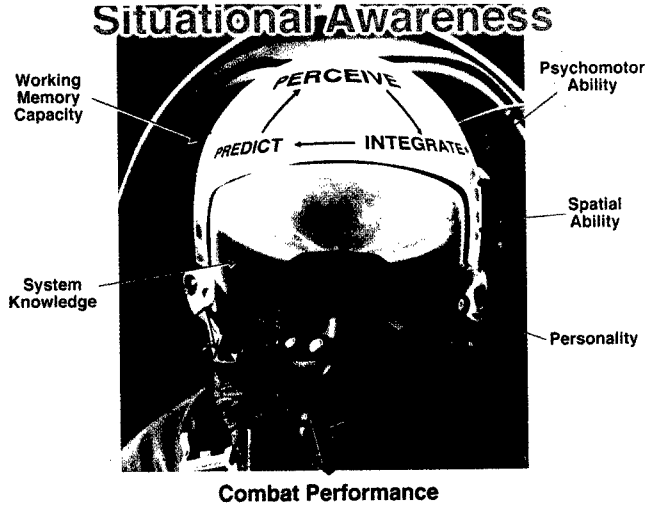
OPR: HSC/YAG, (513) 255-4733 [DSN 785]

Various designs for wear of officer's rank (such as sleeve braid) were evaluated in wear test evaluations.

Pilot Situational Awareness

According to the Air Force Times, many of the friendly fire casualties during Operation Desert Shield/Storm occurred because pilots mistakenly believed they were in free-fire zones. Studies of air combat since World War I have shown that relatively few pilots (4 to 5 percent) account for about 40 percent of the combat kills. These statistics represent both breakdowns and successes of situational awareness. USAF/XO defines situational awareness as "a pilot's continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, and mission, and the capability to forecast, then execute tasks based on the perception."

Situational awareness is a unifying concept behind much of Armstrong Laboratory's human factors research. New display technologies are developed to improve the pilot's situational perception and prediction of tactical trends. New control technologies seek to improve the pilot's capability to execute necessary actions. Selection and training prepare a pilot to accomplish the mission. Armstrong Laboratory has been at the forefront for developing system assessment metrics including tools for pilot workload evaluation. Current research emphasizes developing and validating subjective, performance based, and physiological situational awareness metrics. Armstrong Laboratory researchers have evidence that near-sensory-threshold information processing is an essential and trainable situational awareness skill and are testing a low cost training device. Other Armstrong Laboratory research has identified the critical behavioral components of situational awareness in multiship air combat. This information is being used to develop training guidelines and devices.

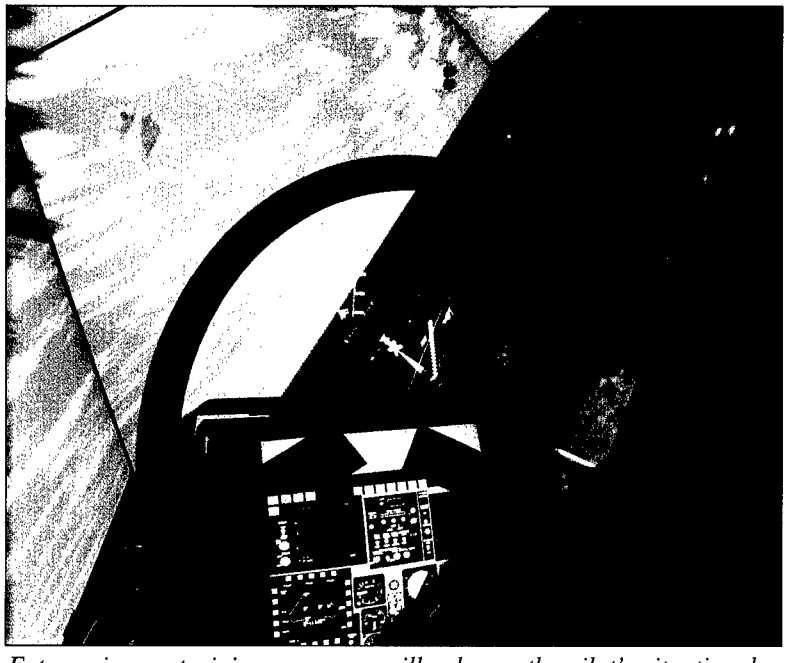


The Situational Awareness Challenge: The measurement of pilot characteristics and behavior to enhance selection, training, and design which are the pillars of combat effectiveness.

In a response to a request from the USAF Chief of Staff, Armstrong Laboratory researchers formed the Situational Awareness Integration Team known as SAINT to perform a quick response research program. The program has three main objectives: (1) develop measures of pilot situational awareness, (2) identify tools for selecting pilots most likely to develop good situational awareness, and (3) identify tools for training situational awareness. Armstrong Laboratory scientists have developed two rating scales to elicit expert judgment on pilot situational awareness performance. A computer based selection test battery has been developed to measure fundamental cognitive dimensions of situational awareness. In addition, the test battery includes some tactical game-like software that may train important situational awareness components. The program includes a validation of the scales and selection tests to be conducted in the high fidelity Multiship Training Research and Development facility at Williams AFB AZ. Air Combat Command is fully supporting this program with critical pilot resources.

OPR: AL/CFHP, (513) 255-8750
[DSN 785]

Training for Situational Awareness



Future aircrew training programs will enhance the pilot's situational awareness during combat.

While success in air combat requires a certain level of competence in both procedural and perceptual motor skills, it is the general consensus that the most important skills are cognitive in nature. Throughout air combat, pilots are continuously gathering information from the environment, making judgments about the intent of their adversary, deciding upon the best course of action from a larger set of alternatives, evaluating the success of their actions, and deciding when their chosen course of action is no longer appropriate. Such behaviors have been included under the umbrella concept of "situational awareness" or SA.

A cross directorate research program has been initiated to address issues of measurement, selection, cockpit design, and training. Of specific interest to the Armstrong Laboratory Aircrew Training Research Division is the issue of how to train for enhanced SA during tactical flight operations. Specifically, the objectives are to: (1) develop and validate measures of SA and its components for air combat operations; (2) develop and validate quantitative models of aircrew behavior during air combat; (3) conduct controlled experiments investigating components of SA in an attempt to determine the underlying situational assessment, judgment, and decision-making processes employed by tactical pilots during combat operations; and (4) develop and evaluate training methods and techniques for measurably improving SA during combat operations.

The long-term goal of this research program is to gain an understanding of the components of SA, to determine which elements are most crucial to success in air combat, and to develop training programs designed to enhance a pilot's SA during combat. Such an understanding should lead to a better characterization of differences between novices and experts and, more importantly, how these differences develop. Without a basic understanding of this skill development process, training will likely continue in its current haphazard process in which expertise simply "emerges" as a function of practice. Given the likely decrease in training resources, the preferred alternative would be to "shape" expertise. However, without an understanding of the basic decisional components of air combat, such a prospect appears unlikely.

OPR: AL/HRA, (602) 988-6561 [DSN 474]

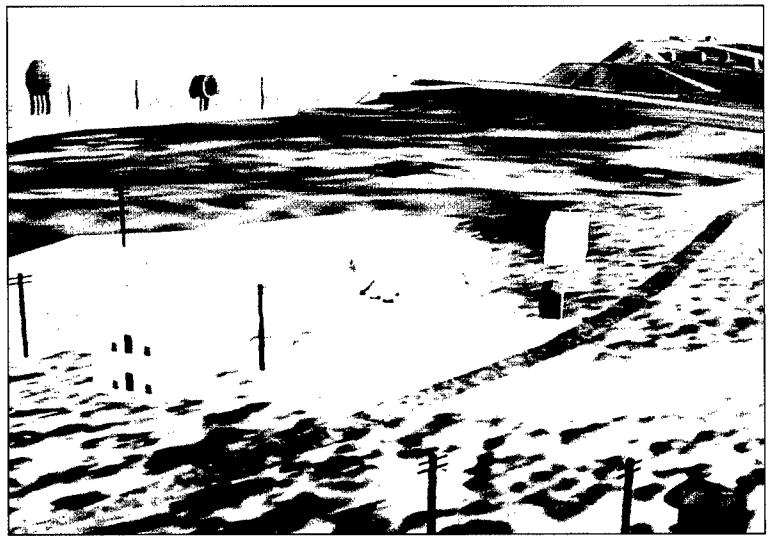
Aircrew Training Systems

USAF aircrew training programs are designed as integrated systems of academic coursework, simulator instruction, and flight training. Recent advances in training technology provide new techniques for USAF aircrew training. There is also a shift toward contracting the design, delivery, and support of aircrew training. A number of technical and management issues must be considered to maximize effectiveness and control costs. The aircrew training system research program provides principles, procedures, and user-oriented guidelines to support USAF acquisition and operational training agencies.

The initial phase of this research effort produced the Model Aircrew Training System (MATS), a major design effort that used modern learning theory to restructure how aircrew training is conducted. The C-130 Aircrew Training System (ATS) specification was based on MATS principles and implemented at Little Rock AFB AR and six other operating bases. An analysis of cost and training effectiveness data from the old and new training systems revealed a reduction in cost with the new approach, largely from reductions in flying hours and numbers of instructor personnel needed. Lessons learned during acquisition, development, and implementation of the C-130 ATS were documented. Evaluation and training information issues, requirements, and key design features are being described based on lessons learned and extensive analyses of operational USAF training programs and organizations.

Armstrong Laboratory's Aircrew Training Research Division recently initiated a research partnership with the Special Operations Forces (SOF) community to address training system effectiveness and mission rehearsal issues, taking advantage of newly acquired rehearsal capabilities collocated with the SOF formal school at Kirtland AFB NM. The goal of the rehearsal research is to develop guidelines for effective integration of emerging rehearsal technologies into the mission preparation process and to document the impacts of these technologies.

OPR: AL/HRA, (602) 988-6561 [DSN 474]



Simulator photo of special operations mission.

Multitask Trainer

The Multitask Trainer (MTT) is a research and development effort aimed at providing a squadron-based trainer. This goal led to the following requirements: a high-fidelity training environment (including cockpit fidelity, real time simulation, and networking for team training); a "pilot-friendly" low cost flexible and extensible design; modular hardware and software; a small package for a classroom or deployment, and concurrence. The physical device is a fully functional three-dimensional cockpit with all cockpit controls and incorporates F-16C aircraft simulation. The air conditioning and the computers necessary to drive the real time simulations, cockpit instruments, instructor/operator station, and a one-channel visual are self contained. The MTT can be split apart to fit through a 36-inch doorway and requires only three 110-volt, 20-amp circuits, ensuring access to any squadron classroom. It uses actual aircraft code to ensure high fidelity avionics and concurrence. Existing high fidelity Air Force owned operational flight-trainer (OFT) software provides the aircraft simulation. Government owned software was converted to keep development costs and risks low, while maintaining the highest fidelity simulation in existence. The MTT is a 5- by 6-foot box that can be produced at a fraction of the cost of an OFT. It is capable of training many mission critical tasks at the squadron level and can be deployed with the unit to continue combat mission training in the field.

A simulator using actual aircraft avionics software modules not only provides concurrence but also offers many opportunities in programs other than training. The MTT design could provide in-depth test of proposed line replaceable unit updates prior to aircraft tests. These updates could be prototyped and even put into specified squadron trainers for user feedback prior to design freeze. The same concept could be carried into new aircraft development. In this case the prototype/trainer software becomes the designed, written, and tested aircraft code.

The technical success of the program and its impact on the future of aircrew training device design led the Air Force Materiel Command to select the MTT program as the USAF "Technology Demonstrator" for the 1992 international air shows. Armstrong Laboratory's Aircrew Training Research Division (AL/HRA) is conducting the program with an in-house contractor. The first device was delivered to the 926th Fighter Group in New Orleans, LA in August 1992.

OPR: AL/HRAD, (602) 988-6561 [DSN 474]

The F-16C Multitask Trainer provides high fidelity training within a portable platform costing only a fraction of existing trainers.

Night Vision Device Training Research

The capability afforded by Night Vision Devices (NVD) for the conduct of nighttime military operations has literally revolutionized modern warfare. Certainly, the recent war in the Persian Gulf was a convincing demonstration of an overwhelming military advantage due in large part to night vision technology. NVDs, primarily night vision goggles (NVG) and forward-looking infrared (FLIR) sensors, have become an integral part of night operations for many aircraft, both rotary and fixed-wing. While NVDs impart a significantly increased capability over unaided night vision, their restricted field of view and reduced resolution (visual acuity) are somewhat deficient when compared to unaided day vision. In addition, the imagery produced by NVDs has unique characteristics that require specific interpretive techniques which must be learned by the operator. These aspects of night vision technology have a significant impact on operational procedures and training requirements.

It is a certainty that nighttime military operations will receive even more emphasis in the future, but training at night will be constrained by shrinking resources, airspace restrictions, and reduced manning. Cost-effective ground based training systems and facilities will be essential.

(Continued on page 72)

Night Vision Device Training in the "Test Lane"

(Continued from page 71)

To effectively employ NVDs, aircrew members must understand the physiological and operational limitations of the devices. The requirement for USAF-wide NVG aircrew training program was identified in an AFISC Functional Management Inspection of Night Vision Goggles (PN 89-622) and by the USAF NVD Working Group which includes representation from all major commands using NVDs. The Armstrong Laboratory Aircrew Training Research Division, Night Vision Program Office, was established to meet the operational training requirements of both existing and future systems.

After thorough review of existing DOD NVD aircrew training programs, research objectives were developed with user inputs and contributions by subject-matter experts. The first completed product was the NVG Test Lane, which combines a specially designed NVG resolution chart (developed at AL/CFHV) and standardized light source with a comprehensive set of adjustment and assessment procedures. The NVG Test Lane provides, for the first time, a practical means by which NVGs can be adequately adjusted and functionally assessed in an operational setting. This capability is vital not only for initial NVG training, but also for routine preflight procedures in operational units.

A prototype course for NVD ground training has also been developed and is now in use or undergoing implementation by all USAF major commands. Individual modules include (a) Visual Physiology and Spatial Orientation, (b) Fatigue and Circadian Rhythm, (c) The Night Environment and NVD Theory, (d) NVG Adjustment and Preflight Assessment Procedures, (e) Cockpit Procedures and Lighting, (f) Lessons Learned, and (g) Hazards and Emergency Procedures.

Efforts in video media development include the production of individual video tapes that address NVG adjustment procedures and a broad spectrum of NVG effects, limitations, and illusions, and an interactive videodisc to be assessed as a self-paced stand-alone audiovisual instructional aid. Work is also underway on the integration of NVG video into existing interactive computer based training software. Future work will include similar products for FLIR and other electro-optical devices as they become operational.

Basic visual research is underway to enhance our understanding of aided night vision. This includes the investigation of size and distance perception with NVGs and the role of unaided peripheral vision on aircrew performance during NVG-aided flight. NVD visual display effectiveness, training transfer effectiveness, and simulator sickness studies are planned.

Activities in advanced simulation technology involve the development of specialized databases and image generators for NVD simulation and helmet-mounted visual displays designed to provide a low cost, deployable, ground based aircrew training capability.

The objective of the NVD Training Research Program is to produce cost-effective, comprehensive ground based training that prepares aircrew members for the unique aspects of NVD employment and enhances USAF operational capabilities and safety in night operations.

OPR: AL/HRA, (602) 988-6561 [DSN 474]

Multiship Training Research and Development

Realistic training for tactical air-to-ground and air-to-air battle is difficult, dangerous, and costly. Combat mission training for the air combat forces has limitations such as use of tactical ranges, frequency of practice, and capability to rehearse specific missions. Advances in simulation technology are needed for combat training such as affordable training devices, networking for interactive force-on-force training, and rapid turnaround databases for mission rehearsal. The Multiship Training Research and Development (MULTIRAD) project will develop, integrate, and evaluate several simulation and training technologies for this purpose. The focus is on acquisition and maintenance of multiship air-to-air and air-to-ground aircrew combat readiness. The goal is to identify specific training needs for a joint air/land battle exercise and match those training needs to cost-effective training devices.

During 1990, in cooperation with Defense Advanced Research Projects Agency (DARPA), simulator network (SIMNET) version 6.6 was installed, including expansions to include USAF weapon systems. Both local area and long-haul networking of aircrew training devices were demonstrated. Training effectiveness research and development was initiated with ACC to identify combat tasks that could be effectively trained using ground based simulators. During 1991, a variety of training devices were integrated to the SIMNET network. Extensive testing of this expanded protocol was initiated in cooperation with DARPA, Naval Training Systems Center, Institute for Simulation and Training, and industry. Training utility evaluations are underway to identify the training potential of low cost aircrew training devices. During 1992, MULTIRAD directly supported DARPA's efforts in WAR BREAKER. This simulation recreates the last months of SCUD hunting during Operation Desert Shield/Storm.

The MULTIRAD program will provide the simulation and training effectiveness tools needed to enhance critical multiship aircrew skills. This capability will be used to develop and evaluate multiship air-to-air and air-to-ground training systems. Ultimately, results of this R&D will provide the air combat forces with the capability to more realistically train for a joint service air/land battle exercise.

OPR: AL/HRA, (602) 988-6561 [DSN 474]

Realistic Multiship Training.

Intelligent Training Technology

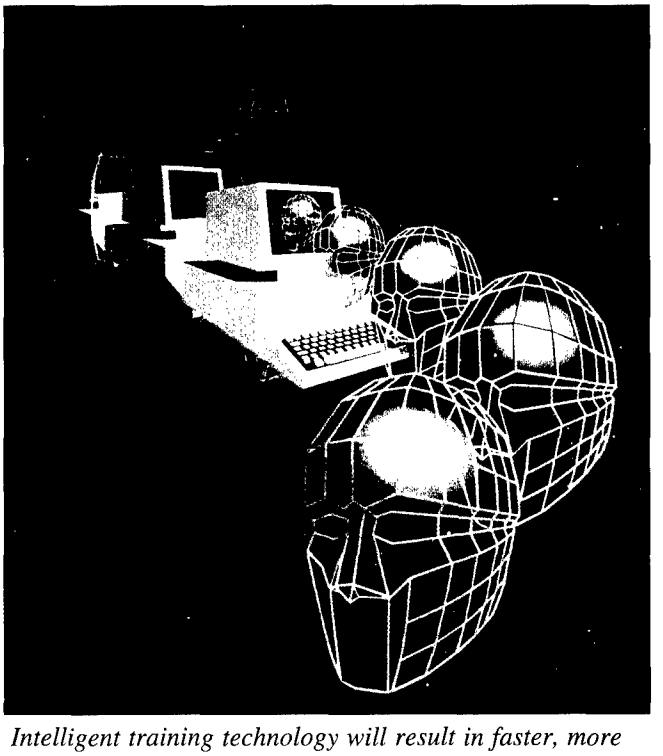
While USAF weapon systems demand increasing levels of technical expertise, the availability of quality trainees is diminishing. Advancements in artificial intelligence enable computerized instruction that adjusts to the knowledge and ability of each trainee. These advancements will enable faster, more effective training of personnel from diverse educational backgrounds and minimize errors in complex maintenance and operations tasks. The Intelligent Tutoring System (ITS) integrates subject-matter expertise, instructional methods, and student modeling to produce human-like tutoring environments. Products of this research include intelligent tutoring systems, intelligent authoring systems, and instructional effectiveness assessment technology. Users of this research include Air Education and Training Command, Air Mobility Command, Space Command, the USAF Academy and NASA.

Completed ITS products include tools for rapid development of expert knowledge bases and tutoring systems. Ongoing efforts oversee the development of tutors for various purposes. For example, the Intelligent Computer-Assisted Training Testbed (ICATT) will support development of intelligent simulation based training systems for equipment maintenance tasks.

An ICATT prototype was completed in 1992. Another example, the Fundamental Skills Research Program addresses the critical thinking skills required for basic literacy in the United States. Test sites for this project were established at eight public schools nationwide during 1992. In addition, subject-matter-specific tutors have been developed for weather forecasting, satellite console operations, auxiliary power unit maintenance, and cryptographic equipment maintenance. Other ongoing research topics address natural language processing, intelligent hypermedia knowledge bases, machine learning, and authoring system capability for microcomputers.

The payoff is faster, more cost-effective training of USAF personnel. ITS will provide greater consistency between technical training schools and on-the-job training, reduced cost and development time for computer based training, and critical technology for the private sector.

OPR: AL/HRT, (210) 536-2034 [DSN 240]



Intelligent training technology will result in faster, more cost-effective training for USAF personnel.

Advanced Instructional Design Advisor

The USAF must provide personnel with technical training for a number of weapon systems and missions. At the same time, we are experiencing a significant cutback in resources to support training requirements and a decrease in the number of instructors. In turn, there will be increased demand for computer based instruction (CBI). The Advanced Instructional Design Advisor (AIDA) project will provide automated and intelligent tools to assist novice instructional designers in the development of effective CBI. AIDA incorporates two technologies from artificial intelligence: case-based reasoning and expert systems. One AIDA component provides detailed guidance for designing CBI for several cases which are fully elaborated and available on line. A second component uses expert system technology to collect and configure reusable lesson frameworks appropriate for a variety of specific instructional purposes.

An evaluation of these technologies in USAF technical training settings has been conducted. Initial results indicate such techniques and tools can be used by subject-matter experts with little background in CBI and development time can be reduced by a factor of ten. An experimental AIDA has been prototyped and is now undergoing formative evaluation. The initial effort will target electronics and aircraft maintenance training. It will provide four on-line cases and four intelligent lesson frameworks. These frameworks will be integrated with a front-end advisor which will query users for information about students, course objectives, and content. It will then provide an initial configuration appropriate to that specific instructional development effort.

The Advanced Instructional Design Advisor project will provide automated and intelligent tools to assist novice instructional designers.

AIDA will enable subject-matter experts to develop effective CBI without extensive training. Use of this technology will significantly improve the productivity of CBI developers and enable the USAF to produce effective CBI without recourse to expensive contract efforts. Additional payoffs include: (1) reduced training time, (2) decreased TDY costs, (3) development and delivery of CBI closer to the workplace, and (4) instruction that can be delivered using distance learning technologies.

OPR: AL/HRT, (210) 536-2981
[DSN 240]

Maintenance Skills Tutor

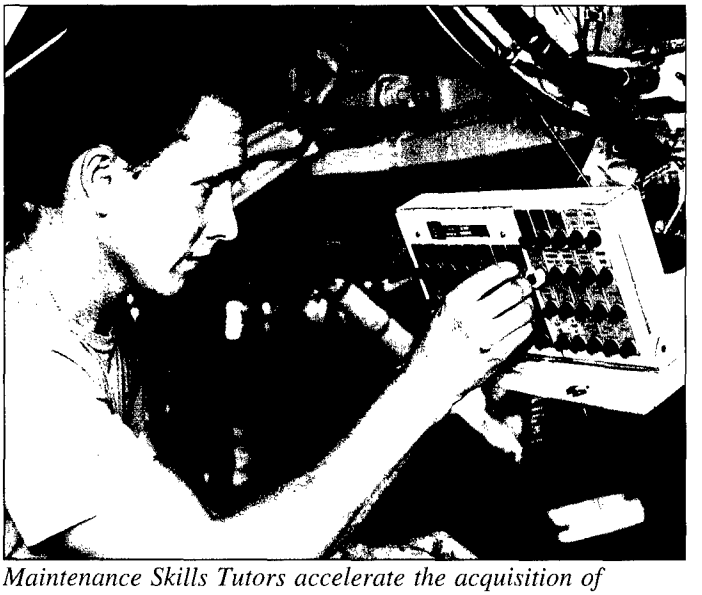
Well trained, productive maintenance technicians are essential to USAF readiness. Today, the thinking skills required for maintaining complex weapon systems and support equipment cannot be adequately taught in existing formal schools and on-the-job (OJT) training programs. In the past, weapon systems and support equipment failed frequently, providing many opportunities for learning through field experience. This is no longer the case because today's weapon systems breakdown less often. In addition, we are reducing the number of technicians per aircraft through the RIVET WORKFORCE program. As a result, each technician must have broader based knowledge and skills. Air Combat Command (ACC) identified a need to improve flight line maintenance technician troubleshooting skills normally taught through time consuming and manpower intensive OJT.

In response to the Air Combat Command need, Human Systems Center's Basic Job Skills (BJS) research program is developing two complementary technologies. First, cognitive analysis techniques were developed to examine novice versus expert troubleshooting strategies and to develop effective training techniques. These techniques are documented in the Cognitive Task Analysis Procedural Guide. Second, artificial intelligence based tutors are being developed to present trainees with a computerized interactive troubleshooting environment for problem solving. They also provide coaching hints and feedback. Prototype tutors were demonstrated at ACC fighter wings at Langley AFB VA and Eglin AFB FL. Novice technicians showed significant gains in proficiency after only 20 hours of training.

The Human Systems Program Office is developing operational Maintenance Skills Tutors (MST) for ACC based on the Basic Job Skills technology. ACC identified this technology as a top priority for fielding. MSTs for tactical aircraft maintenance specialists, flight line avionics, and other USAF specialties are being developed.

The MST effort has several payoffs: (1) faster more complex skill learning, (2) increased adaptiveness and efficiency of technical personnel, (3) reduced need for retraining, (4) increased productivity and ability to carry out the mission. This technology can be transitioned to private sector settings for effective training of complex problem-solving tasks.

MST OPR: HSC/YAR, (210) 536-2477
BJS OPR: AL/HRT, (210) 536-3570
[DSN 240]



Maintenance Skills Tutors accelerate the acquisition of complex skills.

Advanced Training Systems

Even with today's high technological capabilities, training systems remain both labor and paperwork intensive. The effectiveness of training systems can be maximized by carefully blending operational requirements with instructional strategies, student flow, media selection, instructor skill level, lead time, and available resources. The Advanced Training System (ATS) is an interactive computer support system being developed to automate the training processes at Air Education Training Command's (AETC) Technical Training Centers (TTC). When fielded, it will perform and unify training management, development, delivery, testing, and evaluation. The USAF plans to utilize this new capability to control the training services of the TTCs.

The ATS system will perform all functions involved in training including registration, scheduling of courses and students, monitoring student flow through the system, and recording of student evaluations. In addition, ATS will assist the instructor in course development and presentation; ultimately, it will control training from beginning to end. This distributed system of personal computers interfaces with larger computers strategically located to facilitate data storage and network transfer. ATS will interface with the Air Force Training Management System at Randolph AFB TX and other TTCs using existing military telephone and data networks.

The system is designed for maximum portability and hardware independence. Transition to ATS began in 1993 at Keesler AFB MS TTC. This program provides AETC with an integrated, computerized network system which capitalizes on modern interactive media and provides efficient transfer of instructional information throughout the training environment. With the full implementation of this program, training costs will decrease as training effectiveness improves. The ATS can be transitioned to automate any military or civilian schoolhouse environment.

OPR: HSC/YAR, (210) 536-2477 [DSN 240]

Advanced Training Systems will unify training development, delivery, testing, and evaluation.

Base Training System

Several years of hard work and perseverance by the Human Systems Center (HSC) has paid off in the development of a prototype USAF enlisted on-the-job training system known as the Advanced On-the-Job Training System (AOTS). In 1988-89, the Human Resources Laboratory demonstrated the feasibility of this advanced training technology in the operational environments of Tactical Air Command (TAC), Air Force Reserve (AFRES), and Air National Guard (ANG). The system integrated the three main components of training (management, evaluation, and training development/delivery) into one complete training system. The work involved was primarily software development because hardware was to be purchased off the shelf; thus, no hardware was developed. In July 1990 the implementation of the management portion of the AOTS was given the go-ahead with further enhancements to follow in the coming years.

Shortly thereafter, the AOTS program was transitioned to the Human Systems Program Office as the Base Training System (BTS). BTS is an HSC "high-gear" program approach to meet the immediate needs of the user. HQ USAF/DPP (AF On-The Job-Training Policy) serves as the requirements manager. BTS standardizes all aspects of the OJT management processes and allows supervisors and training managers across the active duty, civilian, ANG, and AFRES communities to perform their OJT jobs more quickly and efficiently. The management system (their first priority) software from AOTS was modified to work on the USAF standard AT&T 3B2 minicomputer. The 12th Flying Training Wing at Randolph AFB is conducting an operational assessment of the prototype system. The program is awaiting approval of the Air Force Training and Education Automated Management System requirements board and will upgrade the software prior to USAF implementation.

BTS uses existing base level communications and computer infrastructure to allow for maximum access. It automates training records for officers, enlisted, and civilians to allow real time training requirements and training status to be determined. The BTS has automated interfaces with the Personnel Data Systems to obtain military and civilian personnel data to allow each USAF supervisor to have a current and complete training template for every USAF member. This approach optimizes the reuse of existing data while injecting state-of-the-art OJT management where it is most needed. This fosters greater productivity and enhances the quality of "total person" USAF training.

BTS continues to pursue this state-of-the-art training system in support of today's and tomorrow's user needs. This system can be applied to any military or civilian training management need.

OPR: HSC/YAR, (210) 536-2477 [DSN 240]

Training Impact Decision Systems

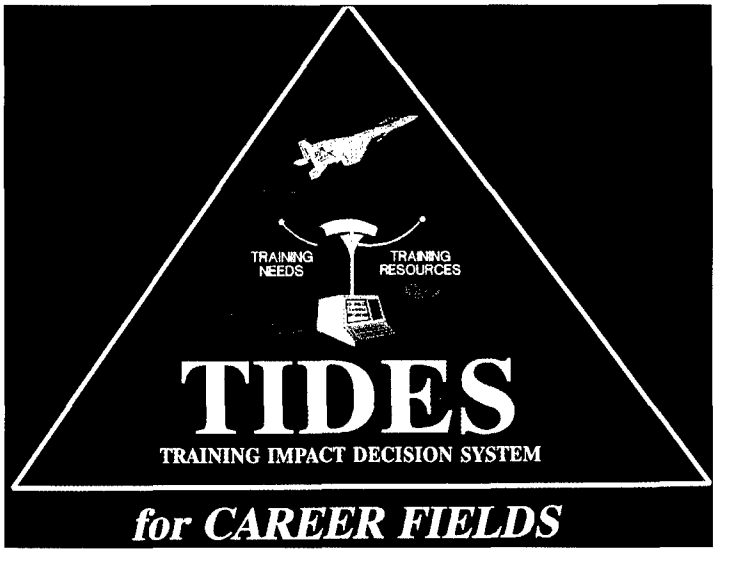
USAF planners and training managers face a complex array of variables when making broad decisions on career field training. Changes in the Manpower, Personnel and Training (MPT) system can have unanticipated long-term impacts. Budget fluctuations, job restructuring, and policy revisions involving training and the force structure add further complexity. The Training Impact Decision System, or TIDES, helps key decision makers recognize the impact of these factors on the training system. TIDES integrates information about jobs, personnel utilization factors, training costs, resource requirements, capacities, and managers' preferences in identifying the optimal allocation of training resources.

TIDES identifies which tasks within a specialty to train, the career points at which training should be provided, and the optimal combination of training settings--formal classroom instruction, self-paced study, hands-on training, or on-the-job training (OJT). Analysts use TIDES to dynamically model the current utilization and training pattern of a specialty and then assess alternative scenarios based on proposed changes to the specialty. For example, TIDES assesses the impact on personnel, resources, cost, and mission resulting from a decision to add or eliminate a training course, front load OJT into technical training courses, or recruit industry trained personnel. Decision makers can use TIDES information to manage career fields, optimize resources, and develop Career Field Training Plans (CFTP). Users of this research include HQ USAF, HQ Air Education and Training Command, and operational major commands.

In 1988, proof-of-concept work was completed on this technology. Exploratory development of the forerunner to TIDES, the Training Decisions System (TDS), included development of training cost and capacity models, the analysis methodology, and supporting data files for eight Air Force Specialties (AFS). Advanced TIDES research is aimed at designing a template for CFTPs and developing a user interface that facilitates data manipulation and analysis.

The payoff to the USAF is a systematic method to enable functional and training managers to maximize efficiency and training effectiveness while minimizing training costs, yet still provide the means to produce the highest quality fully trained forces.

OPR: AL/HRT, (210) 536-2932 [DSN 240]



Training Effectiveness and Efficiency Model

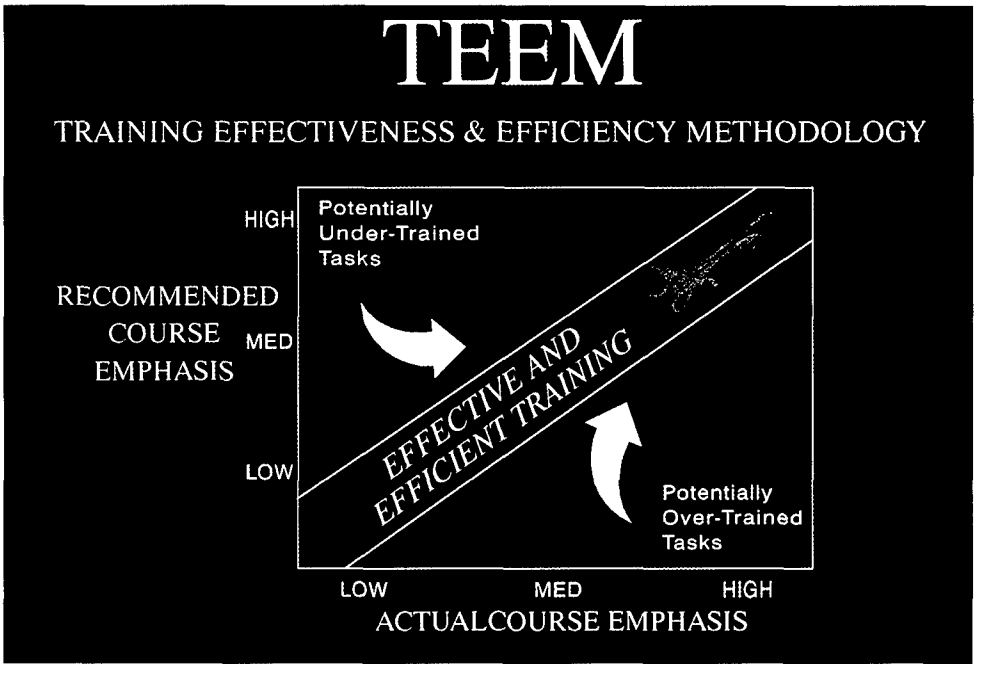
With today's fewer resources and increased complexity of jobs, the USAF will find the Training Effectiveness and Efficiency Model (TEEM) an invaluable asset. The TEEM method will enable the USAF to make knowledgeable decisions in the realm of training. TEEM not only identifies deficient or excessive training, but also helps determine the content validity of that training.

TEEM examines training efficiency with a comparison between field recommendations of task training emphasis and the actual emphasis given in the classroom. Under- and over-trained tasks are quickly identified and revised making the training program revision process both more time and cost efficient.

TEEM methodology addresses the effectiveness of training by examining the job performance and knowledge level of the identified over-and under-trained tasks. These results could then be used to facilitate training course changes. For example, training time might be reduced for overtrained tasks that were performed well, while training time might be increased for undertrained tasks where performance was low.

TEEM, written in IBM compatible software, is applicable to all enlisted and officer specialties for all USAF and military contexts including Active, Reserve, and Guard components. In addition to its military application, TEEM is suitable for civilian training assessment. To date, TEEM has been utilized for the aerospace ground equipment mechanic and aerospace physiology instructor training program analyses. TEEM will provide the USAF with a reliable and accurate feedback device for refining technical training to better meet the field requirements.

OPR: AL/HRT, (210) 536-3047 [DSN 240]



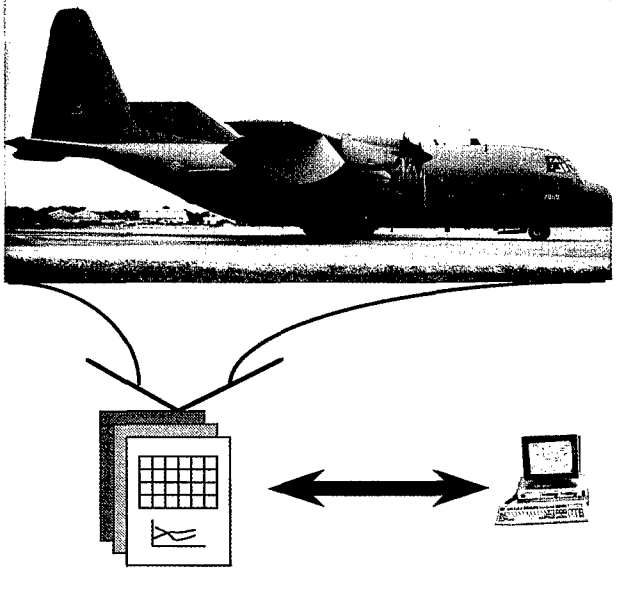
Maintenance Skills Training Studies

USAF maintenance organizations are adapting to new challenges resulting from several significant personnel, technological, and organizational trends as well as budget realities. A growing need to enhance troubleshooting skills, capture lost expertise, and transfer years of maintenance technical experience has generated strong interest in Human Systems Center Intelligent System Technology. Accordingly, major commands need to assess the applicability of tutors to improve maintenance skills and substantiate requirements documents for program funding.

An analysis of an Air Combat Command (ACC) F-16 and F-15 maintenance skills needs and technology assessment was completed to support transition of Armstrong Laboratory technology to the Systems Program Office for the planning of a full-scale development effort. Since the effort dealt with development of an unprecedented system with respect to acquisition, evaluation of software development approach, and programming language issues an initial risk had to be assessed. The study substantiated that use of Intelligent Tutoring Technology was necessary to address ACC needs. In addition, technology assessment and associated supportability issues laid the groundwork for determining applicability of this training technology to USAF-wide maintenance technician training requirements such as for the Air Force Special Operations Command (AFSOC).

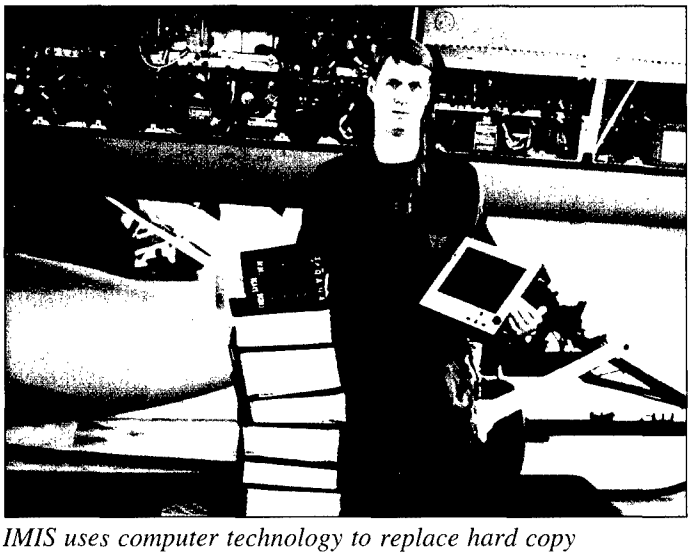
As a natural outgrowth of the original maintenance skills study for ACC, a needs analysis and capability assessment was initiated in FY92 for the AFSOC. The study will provide a basis for AFSOC training program planning. The mission of AFSOC and the different types of aircraft imposed a diversity of maintenance skills required which entailed a study broader in scope than the corresponding study for ACC. The applicability of Human Systems Center training technologies--intelligent tutors, in particular--is being assessed to address AFSOC maintenance-training problems. This will also result in determining the applicability of tutors to other MAJCOM needs and thus foster the improvement of proficiency and efficiency of USAF maintainers.

OPR: HSC/XRS, (210) 536-2424 [DSN 240]



Analysis captures technology application for maintenance training on the flight line.

Integrated Maintenance Information System



IMIS uses computer technology to replace hard copy technical orders and aids in diagnosing maintenance

USAF maintenance personnel are called upon to repair increasingly complex modern weapon systems. Maintenance must be accomplished under a wide variety of deployment scenarios and with fewer maintenance specialties. Technicians must have ready access to huge amounts of technical information to maintain aircraft. The Integrated Maintenance Information System (IMIS) is an automated system which is being developed to provide the technician all of the information that is needed to do the job from a single source.

The IMIS consists of a small Portable Maintenance Aid (PMA) computer, maintenance information workstations, and an aircraft interface panel. The PMA provides technicians with rapid access to all the information required to find and fix maintenance problems. This includes step-by-step instructions, troubleshooting guidance, part numbers, illustrations, and aircraft maintenance history. The PMA directly connects to the aircraft to run built-in tests and extract aircraft system data for use in troubleshooting.

User requirements studies have been conducted to ensure that the system meets the technicians' needs. It is being developed in a phased approach, with field tests being conducted to evaluate each new capability as it is incorporated in the system. In the most recent test, the diagnostic capabilities were tested using the F/A-18 as the test bed. Technicians used maintenance instructions, diagnostic guidance, and the PMA/aircraft interface to identify faults in the aircraft. The test demonstrated that technicians can troubleshoot more effectively when using the IMIS. A full-scale IMIS is presently in development which will demonstrate and test all IMIS capabilities.

IMIS technology will save millions of dollars by reducing maintenance time and by reducing the inventory of spare parts. It will improve deployment capability. Electronic media will replace the vast bulk of paper technical orders. Also, the IMIS will enhance the country's technology base and maximize the return from our investment in weapon systems.

OPR: AL/HRGO, (513) 255-2606 [DSN 785]

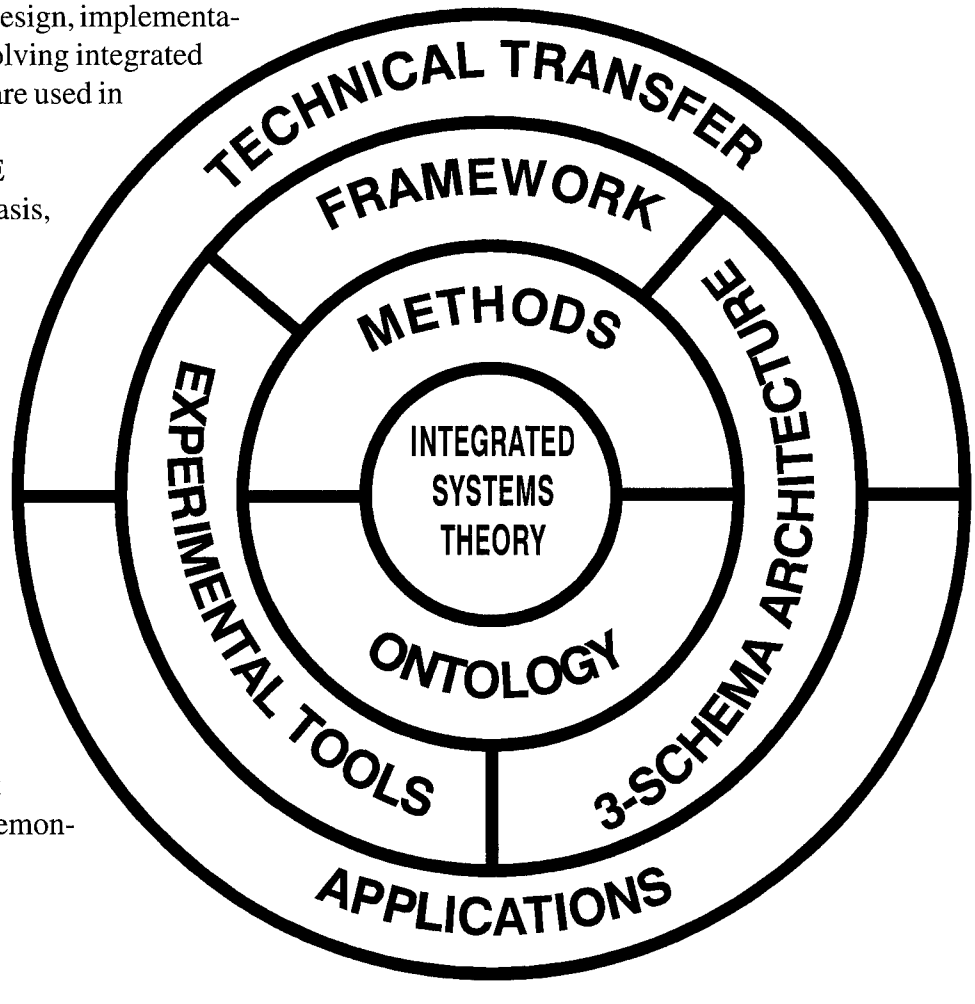
Information Integration for Concurrent Engineering

Modern technology is cursed with inefficiencies in information management; for example, software packages that are unable to input data from other software packages, special-purpose methods and procedures, non-standard data repositories, etc. The overall effect of this diversity keeps organizations from integrating their information. The Information Integration for Concurrent Engineering (IICE) project is developing the critical technologies for information integration in support of concurrent engineering processes. These technologies will provide a structured engineering approach to life cycle activities associated with the definition, engineering, design, implementation, and maintenance of evolving integrated information systems which are used in concurrent engineering.

In order to set the IICE project on a firm scientific basis, the program is designed to have theoretical as well as experimental and application components. This has led to a wide range of user interest: invited participation in prestigious conferences, requests for information from numerous DOD agencies, even funds contributed by the Army Natick Research and Development Center to initiate a concurrent engineering pilot project at their facility. A demonstration is currently being planned at a USAF air logistics center.

The IICE technologies have the potential to save the government millions of dollars by creating the capability for integrated concurrent engineering enterprises. Products include, methods for integrated design, frameworks which guide the choice of design tools, flexible information storage, and a design environment which supports the concept of evolving enterprises.

OPR: AL/HRGA, (513) 255-7775 [DSN 785]



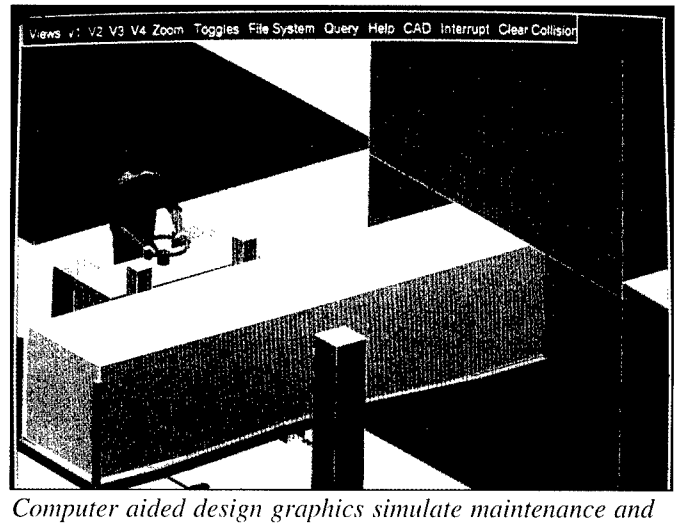
Design Evaluation for Personnel, Training, and Human Factors

Human resources constitute a large share of the cost of USAF system maintenance. If we can account for these costs when systems are being designed, we will acquire more efficient systems. This is the goal of the Design Evaluation for Personnel, Training, and Human Factors (DEPTH) program. DEPTH uses dynamic human figure modeling to present realistic images of people interacting with equipment and the workplace on a computer aided design (CAD) screen. Modern CAD graphics can accurately simulate critical elements of proposed maintenance and repair procedures. We will no longer rely on costly and time-consuming physical prototypes to perform human task analysis. Instead, DEPTH creates a "virtual prototype" for task analysis that allows human/machine interactions to be visualized and manipulated.

The DEPTH task analysis workstation draws on two human modeling technologies. The Armstrong Laboratory's "Crew Chief" provides accurate body sizing, strength and related data on USAF maintainers. The University of Pennsylvania's "Jack" model provides an interactive system for human figure animation and control. We are combining these two technologies into a flexible, powerful, inexpensive CAD graphics workstation for task analysis. New technologies implemented through DEPTH will include virtual reality devices which allow realistic simulation of the work environment and multimedia/hypertext software for "activation" of human performance data. These technologies will simulate a wider range of human abilities and task conditions than current human models. Human performance through DEPTH task simulation will join other engineering disciplines as a full partner in Integrated Product Development. By including human modeling results with Logistics Support Analysis data systems, we will unify the many elements of Human Systems Integration (HSI) involved in system support. Human factors; workplace safety; maintenance manuals; and manpower, personnel, and training domains all rely on DEPTH task documentation. In this way, the Computer aided Acquisition and Logistics Support, or CALS ideas of digital creation, management, and reuse of design data will be served.

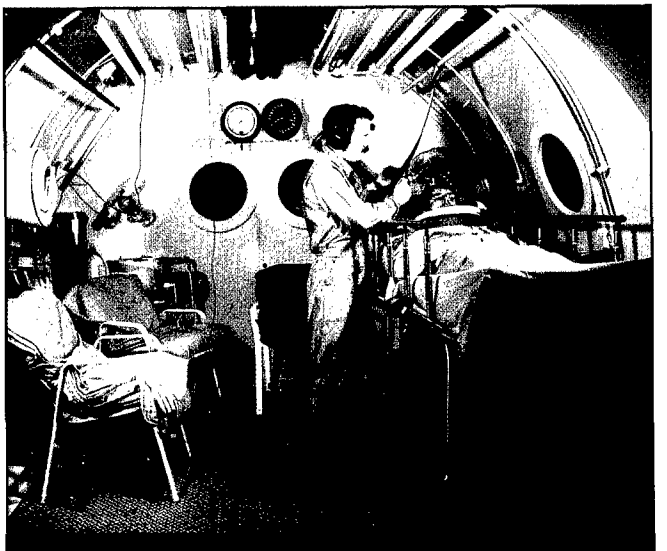
DEPTH technologies are being demonstrated at General Electric Engines in Cincinnati OH and Oklahoma City Air Logistics Center. As new capabilities are added, the range of DEPTH applications will include manufacturing job design and space logistics problems.

OPR: AL/HRGA, (513) 255-6797 [DSN 785]



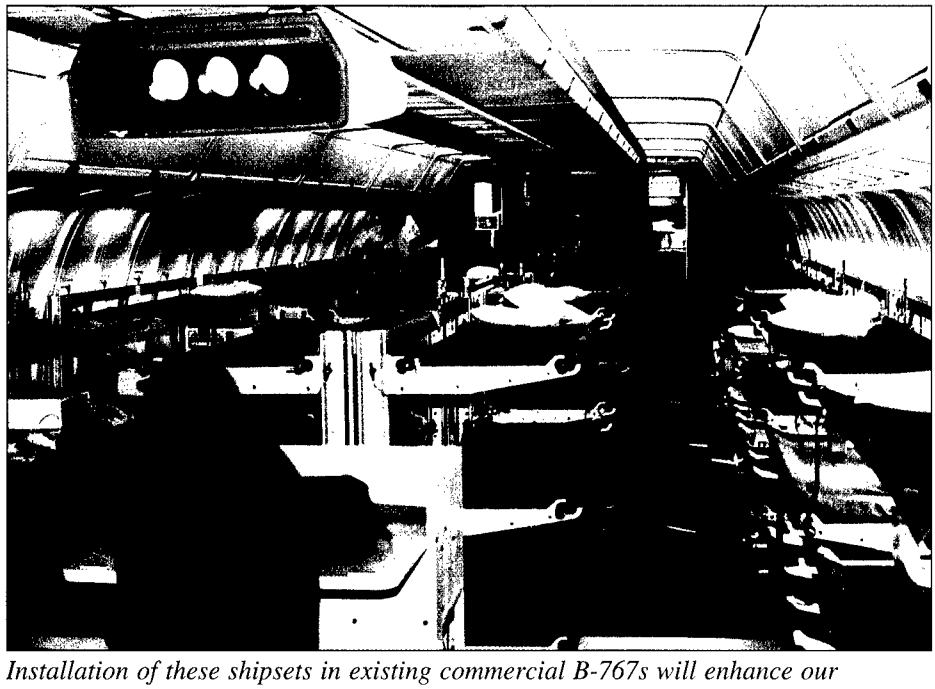
Computer aided design graphics simulate maintenance and repair procedures.

Aerospace Medicine



This Human Systems Center product area provides research and specialized operational support in aeromedical consultation, epidemiology, drug testing, and hyperbaric medicine, as well as development, fielding, and support of aeromedical systems and equipment.

Civil Reserve Air Fleet Aeromedical Evacuation Shipsets



Installation of these shipsets in existing commercial B-767s will enhance our wartime capability to evacuate the injured.

Immediate transport of critically wounded patients from battle zones to medical facilities is crucial for effective treatment. Military airlift capability is augmented by the Civil Reserve Air Fleet (CRAF), composed of civilian aircraft contracted for military service. These aircraft must be converted to enable evacuation of severely injured patients. The CRAF Aeromedical Evacuation Shipsets (AESS) were developed for Air Mobility Command to permit rapid reconfiguration of civilian B-767s during wartime.

CRAF AESS consists of litter stanchions, nurses' workstations, therapeutic oxygen storage/distribution equipment, and electrical power/distribution equipment designed for installation without prior or permanent modification to the aircraft. This enables the B-767 to transport up to 111 litter patients, 40 ambulatory patients, and 10 medical personnel. Shipsets can be installed and removed 20 times (each), stored for 30 years, and can fly for 5,000 flight hours. Full operational capability for the scheduled buy of 34 B-767 shipsets occurred in 1994.

Prior to the end of the Persian Gulf Conflict, 10 B-767 shipsets were produced in an accelerated program to support Operation Desert Shield/Storm. In a departure from the baseline program's concept, which anticipated that reconfigured aircraft would fly to and from civilian airports, the Desert Storm aircraft were flown from East Coast USAF bases to military installations in Germany and England. The shipsets would have allowed 10 aeromedical B-767s to free up, by best estimates, 17 C-141s to exclusively carry war materials, greatly contributing to both care of the wounded and resupply of the war effort.

OPR: HSC/YAM, (210) 536-2664 [DSN 240]

Spinal Cord Injury Transportation System

Safe transportation of spinal cord injury patients between medical treatment facilities is necessary to prevent further trauma to the patient. The objective of this program is to ensure that patients with spinal cord injuries who must be airlifted significant distances receive the same quality of care in transit that would be available from medical treatment facilities. The Spinal Cord Injury Transportation System (SCITS) will incorporate the latest in kinetic therapy including continuous side-to-side motion for treating and preventing complications of immobility, skeletal traction, and stability for the spine.

There are several operational performance parameters that are unique to the SCITS design and its aeromedical evacuation mission. SCITS must be sufficiently light and portable so that four individuals can pick up both it, and the patient, for transport into the medical evacuation aircraft, ambulance, or ambus. Furthermore, this device must fit properly into the standard litter stanchion used onboard those evacuation vehicles. Since medical evacuation aircraft impose additional requirements above and beyond those of an ambulance or ambus, the SCITS must be made of lightweight materials (with a total weight of less than 200 pounds) and must be extremely durable to withstand the rigors of flight. Medical evacuation aircraft on which SCITS will be used include the C-9, C-17, C-27, C-130, C-141, and the Civil Reserve Air Fleet (Boeing 767).

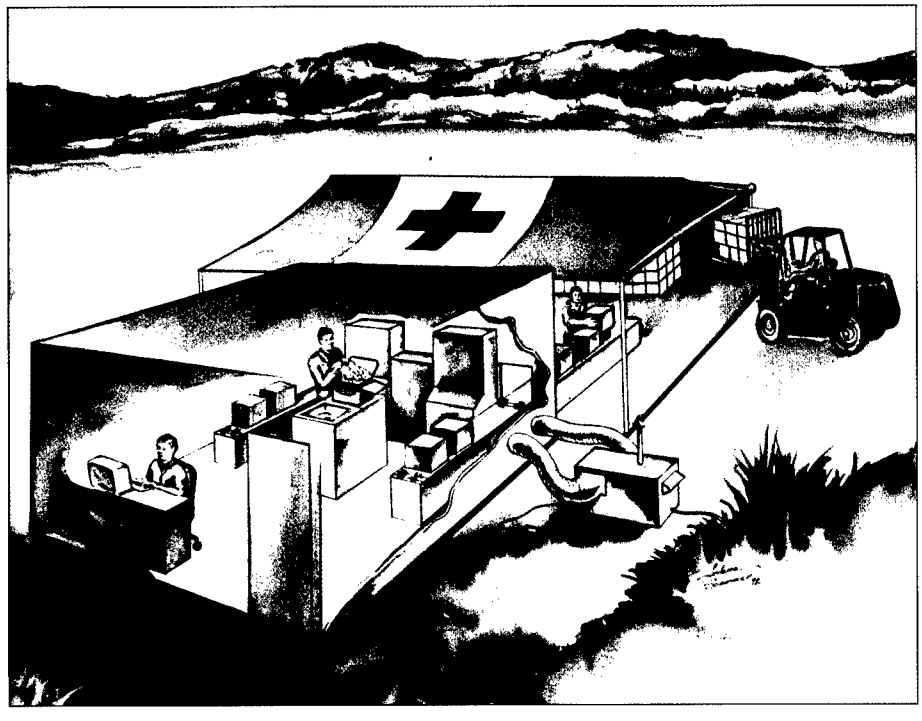
Planned award of the research and development contract is in FY94. Once an acceptable prototype is developed, a production effort will build approximately 180 units. These devices will be fielded in FY97 and will replace the Stryker Frame that is currently used by Air Mobility Command, the USAF Reserve, and the Air National Guard.

Patients with injuries to their spinal cords can be safely airlifted over long distances.

OPR: HSC/YAM,
(210) 536-2664
[DSN 240]

Transportable Blood Transshipment Center System

An urgent need exists for a liquid/frozen blood system to meet future military blood needs. The DOD Military Blood Program Office is responsible for ensuring an adequate blood supply, and the USAF is the lead service for the airlift of blood products. Current blood transshipment facilities are vulnerable, not mobile, and cannot handle large quantities of frozen blood products.



TBTC enables shipment of large quantities of liquid and blood.

The Transportable Blood Transshipment Center (TBTC) system will enable shipment of large quantities of liquid and frozen blood products. Each TBTC includes refrigerators, freezers, ice makers, and shelters to store over 7,500 units of blood. The TBTC provides the capability to communicate and coordinate blood requirements, and it ensures environmental protection of blood products, equipment, and system operators. The TBTC can be transported anywhere in the world and can be operational in 48 hours. An integral part of the TBTC design is the Frozen Blood Shipping Container (FBSC) which will provide thermal protection for up to 48 hours. The FBSC contains a reusable coolant, thus avoiding the problems of shipping blood with dry ice. A prototype TBTC will be developed with a likely follow-on production of seven additional units. The TBTC Request for Proposal was released to industry in late 1990 with contract award in March 1991. Initial operational capability is scheduled for 1995.

The TBTC will allow frozen blood to be pre-positioned in theater. This will decrease the time required to get blood products to the wounded in time of war and decrease the initial demand on our strategic airlift forces.

OPR: HSC/YAM, (210) 536-2664 [DSN 240]

Chemically/Biologically Hardened Air Transportable Hospital

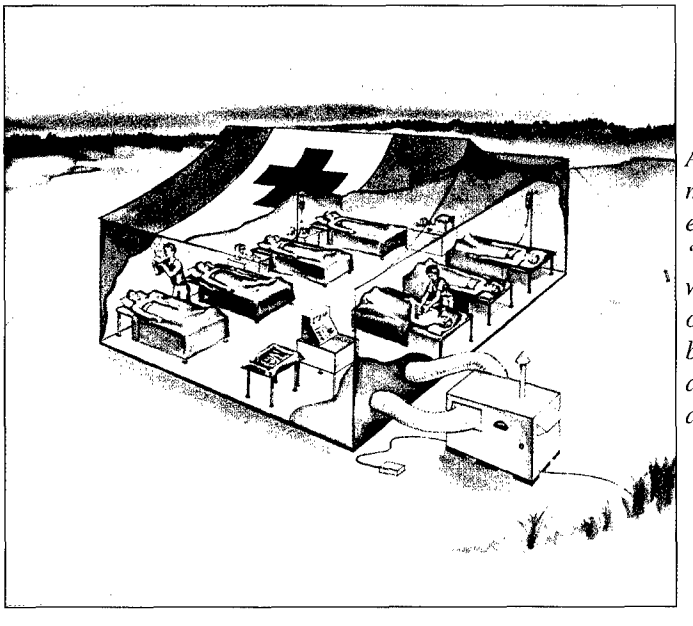
Immediate treatment of injured and wounded personnel is critical to survival and recovery in both combat zones and on humanitarian relief missions. The recent experience of Operation Desert Shield/Storm identified several shortcomings in the current standard of care while employing present Air Transportable Hospitals (ATH). The USAF started the Chemically/Biologically Hardened Air Transportable Hospital (CHATH) to improve the current field medical capabilities of the US Air Force and US Army.

The CHATH program will make four major improvements to field medical care. First, a chemical and biological protection from enemy weapons will be provided for the first time to the medical complex. Second, a constant temperature control will be provided for field patients in all weather environments encountered around the globe. Third, a clean fixed-site hospital environment will be available in the field for the first time. This will prevent the spread of infection and speed stabilization and recovery of patients. Fourth, the field hospitals will be able to admit and treat casualties during active enemy attack instead of waiting until the attack is over. This will greatly speed critical medical care access to the injured. These improvements can be made within the current medical care system.

The CHATH program will modify the current (ATHs) and retain the same medical equipment and personnel. The CHATH program will utilize existing and modified Army equipment to line the current ATH tents and provide an airtight shelter. The Human Systems Program Office is developing a new Chemically/Biologically Hardened Air Management Plant (CHAMP). The CHAMP units will provide chemically/biologically filtered fresh outside air, recirculate and filter interior air to a clean hospital standard, provide heating and cooling, and provide its own backup power for use in blackouts or when electricity is not available.

The CHAMP prototype development efforts began Spring 1993 with full unit testing in Spring 1994. Complete qualification testing will take place in 1995. Two complete hospitals will be assembled and field tested by Air Combat Command in the Summer of 1995. Production of all 27 new CHATHs is scheduled to begin in 1996.

OPR: HSC/YAM, (210) 536-5114 [DSN 240]



An important modification to existing "hospitals" will protect occupants from both chemical and biological attacks.

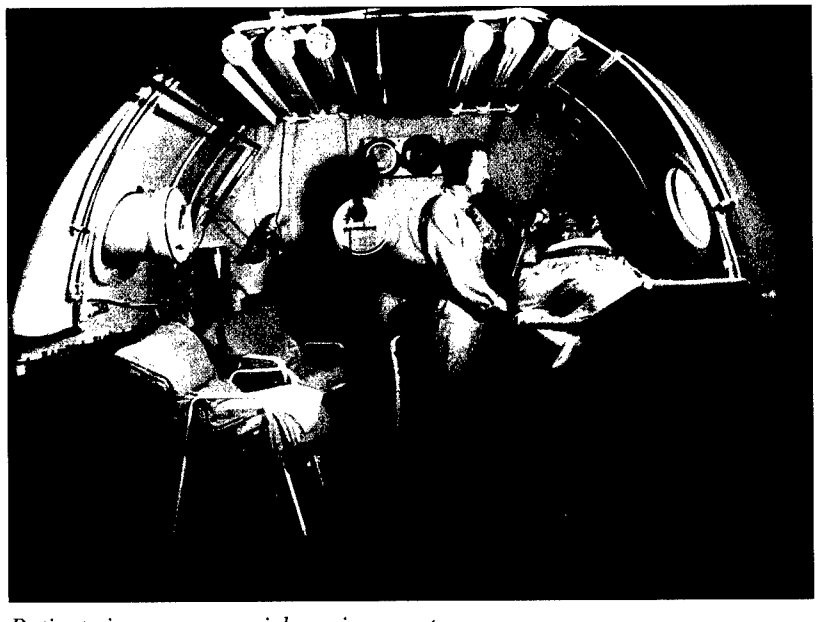
Hyperbaric Medicine

The role of the Armstrong Laboratory Davis Hyperbaric Laboratory (DHL) has expanded tremendously since 1974 when its primary purpose was to treat aviators suffering from decompression sickness. The DHL, is today internationally recognized as a leading center in patient treatment, facility requirements, safety standards, and research using Hyperbaric Oxygen (HBO). HBO is used to treat indicated medical disorders such as chronic nonhealing wounds, carbon monoxide poisoning, osteoradio-necrosis, gas gangrene, and air gas embolism. The DHL presently serves as the lead agency for all DOD Clinical Hyperbaric Facilities and establishes policy for all USAF Clinical Operational (Field) Hyperbaric Facilities. DHL personnel continually work to broaden the understanding, application, and acceptance of HBO therapy through both clinical and basic scientific research. Team members spearhead medical research efforts in the areas of nonhealing wounds, oxygen toxicity, recompression therapy, burns, and crush injury.

To date, our personnel have treated over 3,500 patients. Staff physicians provide worldwide consultation activities around the clock. As the DOD lead agency, the DHL coordinates facility expansion and personnel training including clinical hyperbaric fellowship for US Air Force, US Army, and international physicians, physiologists, and nurses along with enlisted medical and physiology technicians. They have established contacts with private and governmental research organizations in facilities research and assisted NASA in developing specifications for hyperbaric treatment capabilities aboard Space Station Freedom. The DHL leads the way in hyperbaric chamber design and fabrication. Efforts are underway for improved design and construction of facilities including the first concrete hyperbaric chamber. Evaluation of alternate construction strategies may result in greatly reduced construction cost and increased transportability.

The primary payoff is improved overall healing time for many debilitating conditions. This directly translates into reduced hospitalization time and associated medical costs for the DOD. For example, HBO reduces the healthcare cost for treating burn patients by as much as 30 percent. More importantly, the quality of life is immeasurably improved for patients who otherwise face amputation of limbs or continuation of longstanding conditions resolved by hyperbaric oxygen therapy.

OPR: AL/AO, (210) 536-2941 [DSN 240]



Patients in an oxygen rich environment.

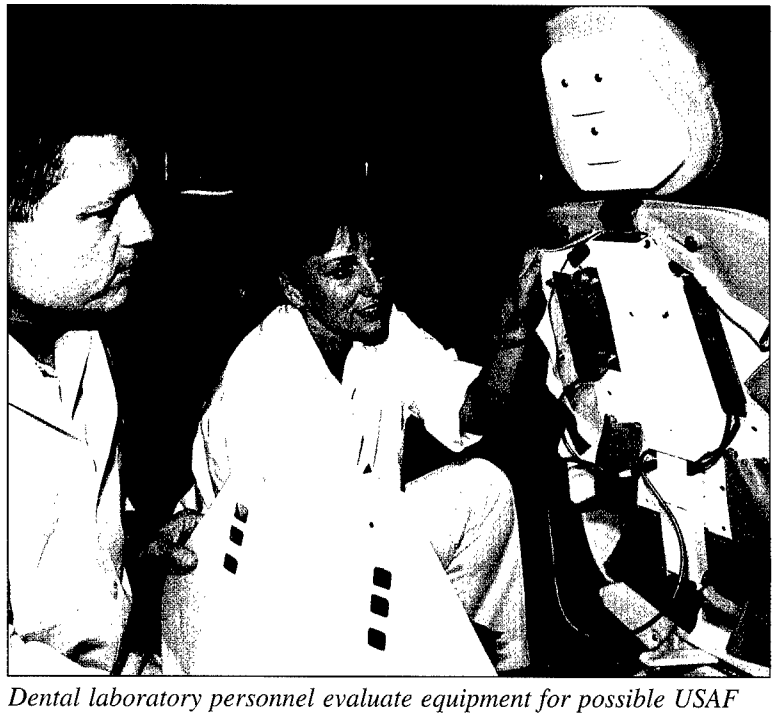
Dental Investigations

USAF medical readiness requires that equipment be appropriate and effective. The USAF Dental Investigation Service (DIS), located at Brooks AFB TX provides a central point for rapid identification and resolution of equipment, material, and facility issues relative to dentistry. The scope includes technical evaluation of commercial equipment and materials for DOD dental use worldwide. DIS conducts a variety of standardized equipment and material evaluations in-house. In addition, clinicians of USAF clinics worldwide perform users' evaluations under DIS direction. DIS provides consultation service for dental construction projects and dental infection control standards for the USAF.

During 1991, DIS performed 54 project investigations, $1.6 million in Equipment Action Requests, and responded to over 4,200 telephone requests for technical information and support from headquarters and operational levels. DIS completed compilation of all patient treatment delivered outside the continental US in conjunction with Operation Desert Shield/Storm (16,000-plus patient visits), and provided an after-action report on material problems encountered by USAF dental personnel deployed during the Persian Gulf crisis. Over 90 facility design actions were accomplished on construction projects valued at over $400 million. DIS publications are sent to over 750 separate federal dental facilities.

DIS maintains close relationships with universities, hospitals, and other interservice agencies and cooperates with national agencies such as the American Dental Association, Federal Drug Administration, and Centers for Disease Control to establish standards for dentistry. DIS has formal agreements with the dental school at the University of Texas Health Science Center in San Antonio and the Naval Dental Research Institute at Great Lakes Naval Air Station.

OPR: AL/AOCD, (210) 536-3503
[DSN 240]



Dental laboratory personnel evaluate equipment for possible USAF use.

Central Military Reference Laboratory

The downsizing of the services has not diminished the requirement to provide cost-effective health care to service members. Advances in technology continue to increase clinician reliance upon diagnostic support services which must now be met within the constraints of tight budgets and limited manpower resources. Under a Congressional Management Efficiencies initiative, the concept of a central military reference laboratory was tested and implemented in order to meet the requirements of USAF medical treatment facilities (MTF) for supplementary diagnostic testing services. This was accomplished through expansion of Armstrong Laboratory capabilities at Brooks AFB TX.

In 1990, after a pilot project with 30 MTF test sites validated the concept while saving $2.3 million during the first year of operation, the reference services were upgraded for an additional 60 clients in 1991-92. Reference laboratory services now provided to 90 USAF and DOD MTFs incorporate a commercial overnight air courier service for specimen transport with a comprehensive laboratory information system. Printers at each local facility produce chartable patient reports within hours of test completion. Among the new clients added were a number of overseas facilities which represented unique requirements for sample transport and data transmission. Unlike many civilian laboratories offering reference services within a region, the new capabilities of the Armstrong Laboratory make it unique among reference laboratories in providing diagnostic services to international clients on a routine basis.

The success of the project is evidenced by the growth in demand for services which increased 30 percent last year. The Armstrong Laboratory reference facility processed over 450,000 computer accessions equating to 1.4 million laboratory tests. A cost/benefit model developed for tracking the project indicates a commercial market value of $8.7 million for the testing performed at a net savings to the USAF of $4.1 million. Client surveys conducted during the year reflect an overwhelming customer satisfaction and are further used to identify new or changing field requirements for diagnostic reference services. New initiatives are underway to further improve services by the addition of remote terminals at client sites and the application of barcode technology for sample accessing and tracking.

Technician analyzes samples to provide support to USAF installations worldwide.

OPR: AL/AO, (210) 536-8378 [DSN 240]

Ophthalmologic Publications

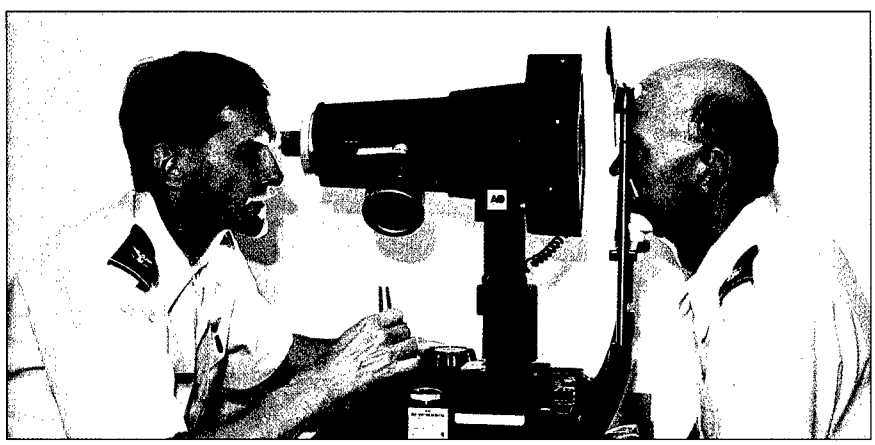
The Ophthalmology Branch of Armstrong Laboratory's Aerospace Medicine Directorate completed long-term research on three Aerospace Medicine Division (HQ AFMOA/SGPA) and Clinical Ophthalmology Branch (AL/AOCO) study groups in 1992. Each study-group research project helped aid HQ USAF personnel in understanding the visual performance limitations of fliers with ocular diseases and conditions and will enable HQ AFMOA/SGPA to set future visual standards for fliers with these diseases and conditions.

The first study group consisted of those fliers with keratoconus, a noninflammatory, usually bilateral corneal dystrophy in which the cornea progressively thins and protrudes causing high, irregular, myopic astigmatism. This leads to visual problems such as blurred vision, diplopia, glare, ocular irritation, photophobia, etc. From 1965 to 1988, AL/AOCO has evaluated 37 flying candidates and fliers with keratoconus. Of these, seven were grounded due to their disease. The other 30 managed to remain on flying status and to fly for hundreds of hours.

From 1979 to 1992, AL/AOCO evaluated 35 flyers who had cataracts removed and a plastic lens placed in one or both eyes. Prior to the use of intraocular lenses, fliers were either grounded or had to wear contact lenses. Intraocular lenses are a significant visual improvement over contact lenses. All of our fliers achieved 20/20 vision in each eye; 81 percent even achieved 20/15. Serious complications were low. All were deemed visually qualified to return to flying status at some point, and some successfully flew hundreds of hours. This surgical technique appears to be an extremely useful method of visual rehabilitation of fliers.

From 1977 to 1988, AL/AOCO evaluated 50 fliers who had ocular Pigmentary Dispersion Syndrome (PDS). We found, through our research, that those fliers with PDS but without elevated intraocular pressure (IOP) rarely progress. However, of those with PDS and elevated IOP, 50 percent developed glaucoma. Thus, additional screening of flying candidates merely for the pigment dispersion is unnecessary. Those with pigment dispersion and elevated IOP should be identified by tonometry. Of the fully trained fliers (with or without elevated IOP), many flew hundreds of hours with proper follow-up and treatment.

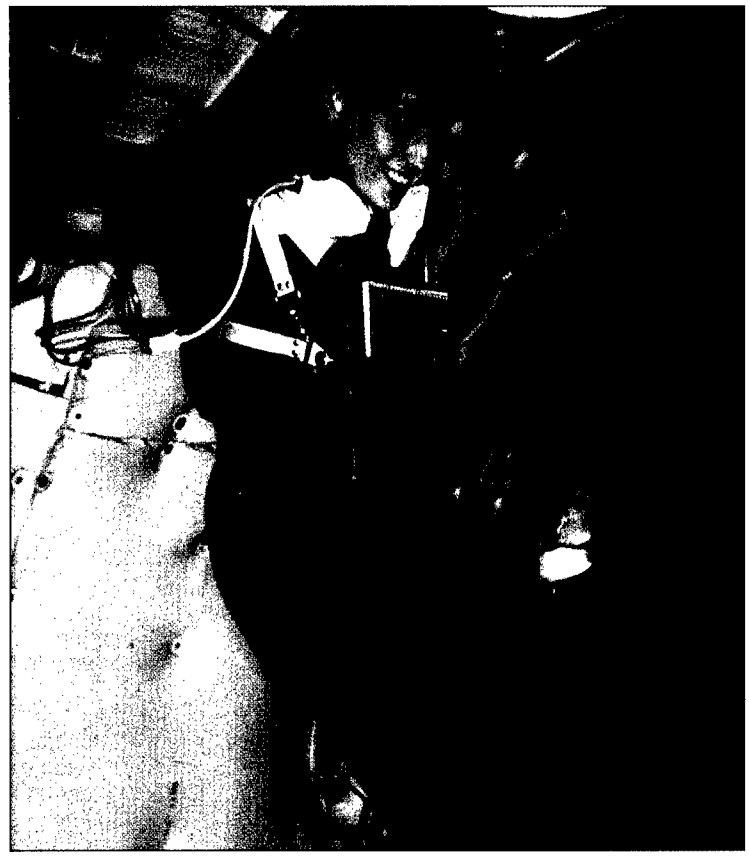
OPR: AL/AOCO, (210) 536-3250 [DSN 240]



Armstrong Laboratory physician evaluates intraocular lenses in an Air Force flier.

Laboratory for Aerospace Cardiovascular Research

Sixty percent of all grounding is cardiovascular related. This represents a significant loss to DOD in terms of experienced aircrew and training expenditures. The Laboratory for Aerospace Cardiovascular Research (LACR) is a joint US Army/US Air Force effort sponsored by the Armstrong Laboratory to gain further understanding into the basic physiologic and pathophysiologic cardiovascular effects induced by the aerospace and aeronautical environments. The aeromedical community will use LACR research results to help further define physical standards for selection and retention of aircrew and address cardiovascular issues as they relate to occupational medicine concerns.



Subject undergoes parabolic flight testing to study effects of weightlessness on the heart.

Recently, the LACR professional staff have published papers and given numerous presentations at national and international scientific meetings on the results of KC-135 testing. Testing centered on central circulatory hemodynamics and our ability to predict responses during altered gravitational states. New findings were presented concerning calculations for total peripheral resistance and ventricular vascular coupling. Transesophageal echocardiography and Evans blue dye were utilized during the parabolic KC-135 flights to investigate fluid shifts during initial entry to microgravity. This was done to simulate conditions and results discovered during space shuttle flights. Many of the successes seen in this program are the result of our recent biosensor technology developments, including advancements in chronic animal instrumentation and Doppler flow techniques.

OPR: AL/AOC, (210) 536-3202 [DSN 240]

Aircrew Aeromedical Standards

Medical standards for aircrew are dynamic, changing in response to operational environments, advanced diagnostic tools, and research. As the USAF center for operational aeromedical science and technology, Human Systems Center validates existing standards and recommends new standards to select and retain crewmembers. Each year approximately 700 grounded crewmembers are evaluated for medical qualification, with over 75 percent returning to duty. The immediate payoffs are retention of experienced personnel and avoidance of the new training costs. The long-term payoff is the refinement of aeromedical standards.

In 1992, the Supraventricular Tachycardia (SVT) study group was reviewed. Four hundred and thirty crewmembers with a mean followup of 11.4 years were studied. SVT is a cardiac rhythm disturbance of the upper chambers of the heart. The effects of the arrhythmia may range from no effects to incapacitation, but the great majority of crewmembers tolerate SVT quite well. Long-term follow-up studies have identified the approximately 10 percent of our population with SVT which would be unacceptable for return to flying. These observations will be used by the USAF Surgeon General for liberalization of waiver criteria for SVT.

The Aeromedical Consultation Center, at Brooks AFB TX is committed to support USAF readiness aggressively and economically with due concern for flying safety and the aircrew health. The aircrew standards programs returns fully qualified aircrew members to duty and provides recommended medical standards for flight qualification.

OPR: AL/AO, (210) 536-3836 [DSN 240]

Evaluation board meets to set new medical standards for USAF fliers.

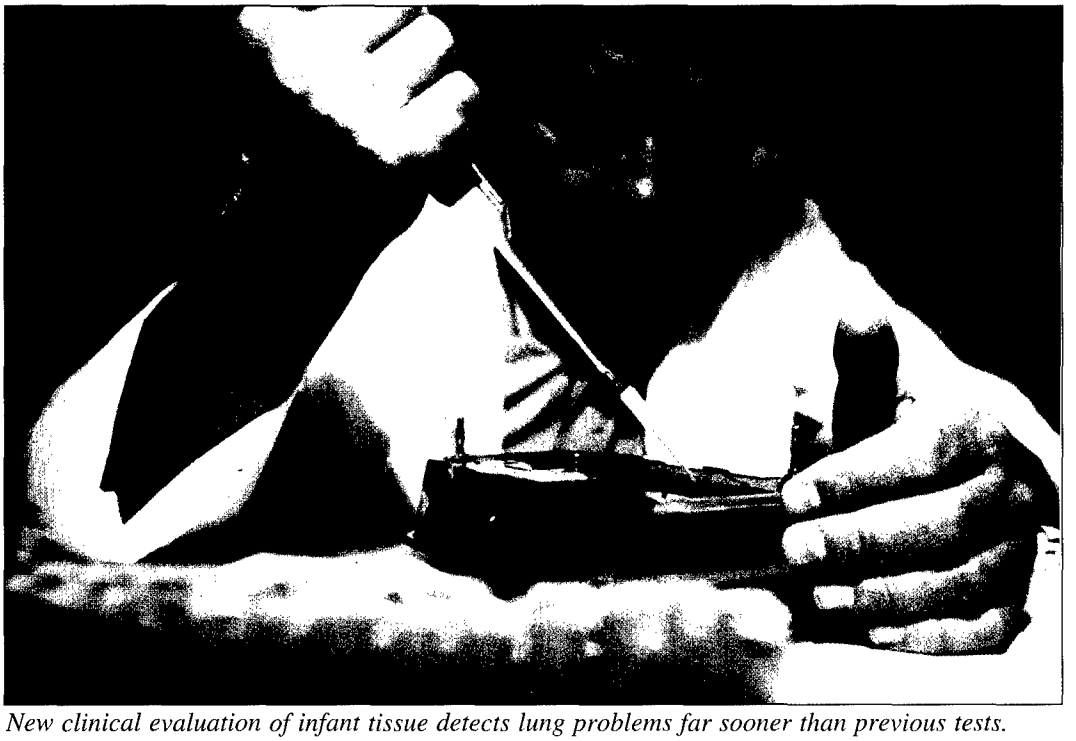
Multi-Probing System for Rapid Identification of Mycoplasma

Mycoplasmas are the smallest free-living organisms. These microorganisms cause life-threatening lung disease in premature infants. Diagnosis and treatment are often delayed because these organisms grow slowly and cannot be identified with the usual medical laboratory techniques.

A system has been developed to specifically probe and identify the Deoxyribonucleic Acid (DNA) of these organisms in clinical specimens. Clinical evaluation has shown 100 percent agreement between this DNA probe and traditional methods performed on specimens from newborns to two years. One patent is pending, and a technical paper has been published. Additional DNA probes are in development. These should be of great clinical value.

Research in the application of these techniques to rapidly identify organisms that cause toxic intestinal infections is ongoing. These infections have frequently caused problems during military deployments and combat operations.

OPR: AL/AO, (210) 536-8382 [DSN 240]



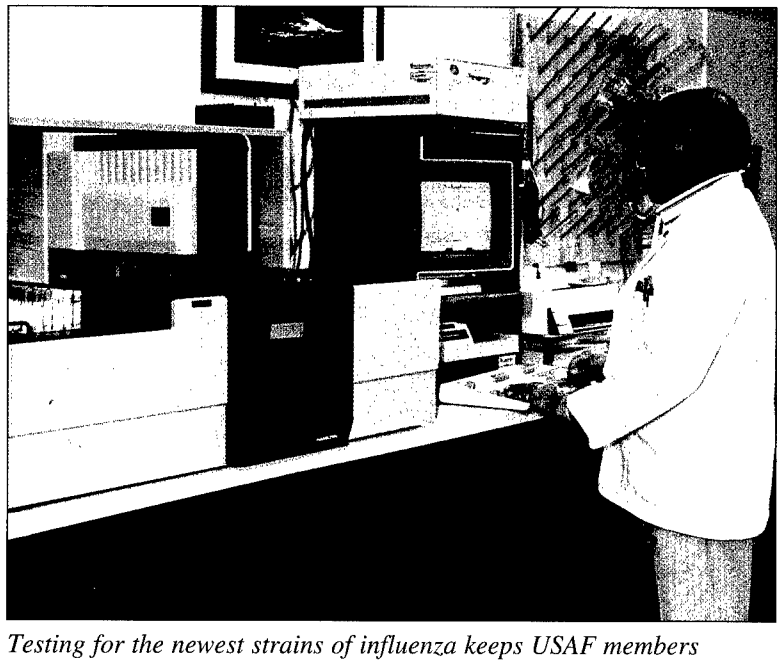
New clinical evaluation of infant tissue detects lung problems far sooner than previous tests.

Project Gargle: Influenza Disease Surveillance

Project Gargle is an integral part of the World Health Organization (WHO) collaborating centers for influenza, via the Centers for Disease Control (CDC), in the United States. In the WHO program, the Armstrong Laboratory Epidemiology Services Branch provides the CDC with a weekly summary of upper respiratory infection/influenza morbidity rates and the number of viral isolates. Data are provided by 14 sentinel USAF bases (six in the continental US and eight overseas) and are unique within DOD. Depending on the time of year and base location, the "target number" of weekly specimens submitted ranges from four to eight. Specimens are screened for seven types of respiratory viruses: influenza A and B, Respiratory Syncytial (RSV), adenoviruses, and parainfluenza (1, 2, and 3).

In every war, respiratory illness has denigrated readiness to a greater extent than combat related injury and death. The annual results of Project Gargle are used by the National Civilian Advisory Committee on Immunization Practices in reaching decisions concerning influenza vaccine formulation. The USAF's influenza immunization program serves as the key preventive medicine program for reducing the impact of influenza in the active-duty population. The success of the USAF Project Gargle program requires close cooperation between the medical staff, laboratory technicians, and military public health team to ensure that appropriate and adequate specimens are submitted. This is a very successful preventive medicine program with worldwide impact.

OPR: AL/AOES, (210) 536-3471 [DSN 240]



Testing for the newest strains of influenza keeps USAF members healthy.

HIV Screening Process

In 1985, DOD directed the screening of all military personnel for human immunodeficiency virus (HIV) and evaluation of the medical status of those infected. In response, the Armstrong Laboratory's Epidemiologic Research Division began a two-year screening of USAF personnel in August 1986 to estimate the prevalence of HIV infection. A second two-year screening of USAF personnel began in October 1988 to estimate the incidence of new HIV infections.

Technician performs HIV screening.

The first screening of USAF personnel ended in September 1988 with a prevalence of 0.95 infections per thousand individuals. The second screening of USAF personnel ended in September 1990 with an estimated incidence rate of 0.21 per thousand; lowest in DOD. The low incidence supported a five-year test interval, coinciding with the periodic physical, to monitor for changes in the incidence of HIV infection. Increasing the testing interval to five years resulted in an annual test volume reduction. This volume reduction enabled the Epidemiologic Research Division to handle all tests "in-house," which reduced costs 60 percent.

HIV screening assists in monitoring the readiness of USAF personnel in both mission performance and deployment. The ability to search a repository of HIV test results supports battlefield blood transfusion and blood bank lookback programs. Testing by the Epidemiologic Research Division has resulted in fewer administrative requirements for submitting units, decreased turnaround times for results, and closer integration of submission procedures into those of normal clinical testing.

OPR: AL/AO, (210) 536-8934 [DSN 240]

Drug Testing

As one of the eight DOD drug abuse detection laboratories, the Armstrong Laboratory's Drug Testing Division is the sole USAF laboratory implementing the DOD drug testing program. Their mission is to deter the use and abuse of controlled and illegal substances by military personnel through a comprehensive drug testing program. Supporting the DOD objective to provide a drug-free, mission ready force and workplace, the Drug Testing Division is a key player in the field commander's ability to maintain a healthy operational ready force. Over 800,000 member and quality control tests were performed in the past year.

The Drug Testing Division began testing United States Air Forces Europe in June 1992 and is currently transitioning drug testing support for Pacific Air Force personnel.

To support all USAF components worldwide, personnel in the Drug Testing Division incorporate strict chain-of-custody and quality control procedures with advanced laboratory technology. The Division analyzes more than a quarter million member specimens each year for evidence of drug abuse to include marijuana, LSD, cocaine, amphetamines, barbiturates, opiates, PCP, and others.

Serving as a reference laboratory for the National Institute on Drug Abuse Certification Program, the Drug Testing Division helps set the standard for other laboratories to follow.

Armstrong Laboratory's drug testing results are among the most accurate in the world.

OPR: AL/AOT, (210) 536-3723
[DSN 240]

Preventive Medicine Consultation

The Armstrong Laboratory's Epidemiologic Research Division consultants manage infectious chronic and environmental disease surveillance programs. They analyze USAF, DOD, state, national, and international morbidity and mortality data and provide consultation to medical treatment facilities, major commands and the Headquarters Air Force Medical Operating Agency at Bolling AFB DC.

An epidemiologist, a public health officer, and two physicians serve as consultants. They provide hundreds of consultations quarterly. This support ranges from developing immunization recommendations and disease control strategies to providing guidance for Aerospace Medicine resident projects to assist development and fielding of fitness and other line-mandated programs. The continuous flow of consult requests is processed by a weekly rotation of the consultants whose primary responsibility is to coordinate this support.

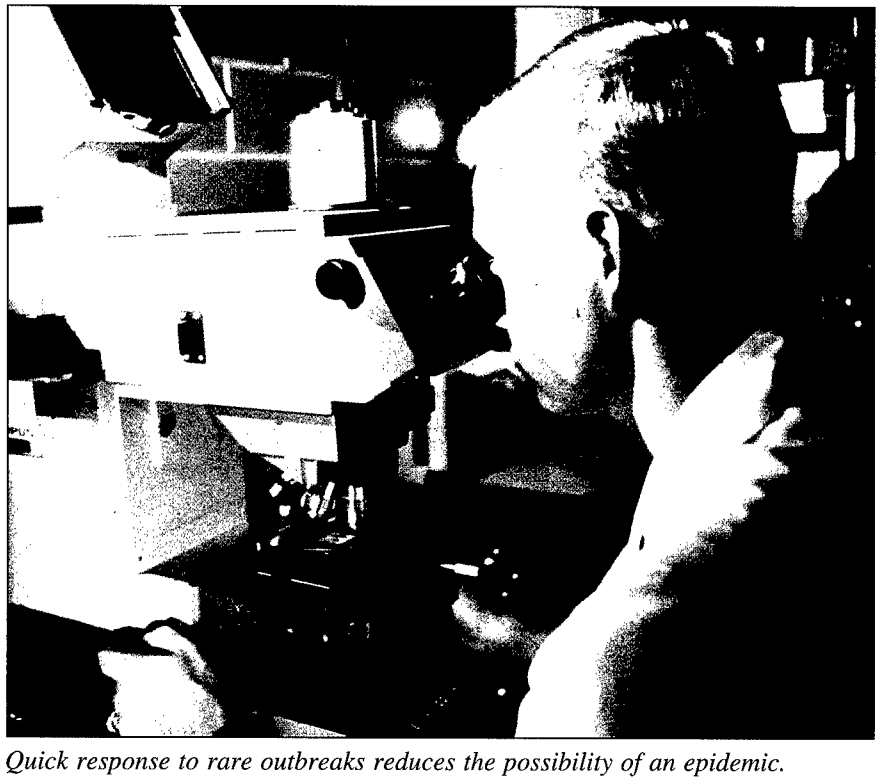
Consultants also serve as investigators in numerous research programs and represent the USAF at national and international symposia. For example, at the 1991 Advisory Group for Aerospace Research and Development Conference held in Rome, Italy, USAF research findings on hepatitis, vaccine preventable diseases, and the human immunodeficiency virus were presented. Ongoing research efforts include analysis of USAF alcohol related morbidity and mortality and a descriptive study of the USAF hepatitis experience from 1980-1989.

OPR: AL/AOES, (210) 536-3471 [DSN 240]

Physicians provide specialized consultation on a regular basis.

Outbreak Investigations

The investigation of disease outbreak is an important part of the mission of the Armstrong Laboratoy's (AL) Epidemiology Services Branch. Outbreaks can involve communicable diseases, injuries, occupationally related illnesses, foodborne illness, and even cancer. Surveillance systems initially note the occurrence of an apparently increased trend in a disease or syndrome, perhaps a cluster of illnesses related temporarily by location or exposure history. The AL Epidemiology Services Branch responds to USAF or DOD requests for assistance in investigating the apparent disease outbreak.



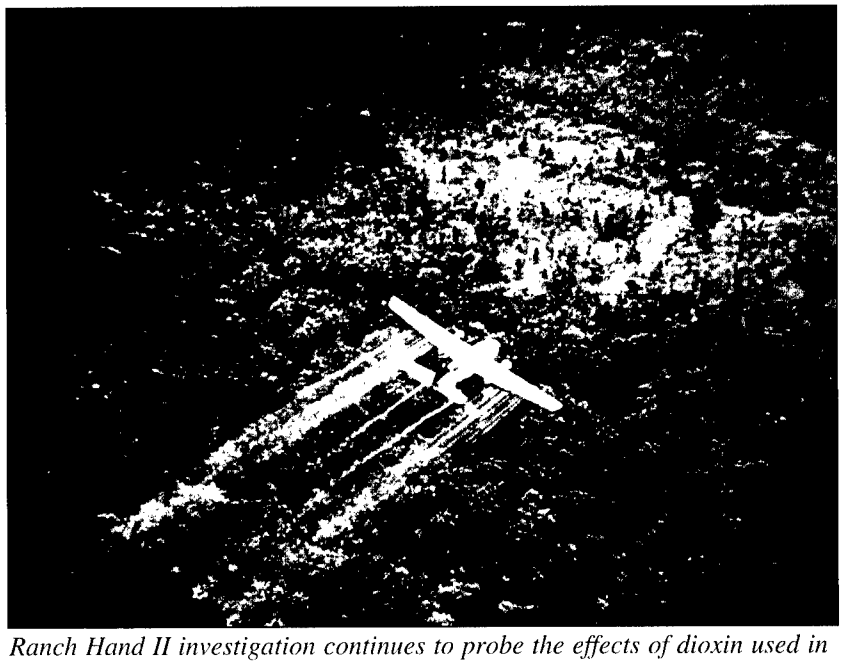
Quick response to rare outbreaks reduces the possibility of an epidemic.

An actual outbreak investigation involves collecting and analyzing data on the cases of illness or injury. Similarities (age, race, sex, or squadron) between cases can provide evidence of epidemiologic links and elucidate the circumstances of occurrence or spread. Once these associations are defined, control measures can be implemented to stop an outbreak and prevent a recurrence.

Recent examples of outbreaks include 900 cases of foodborne illness at the USAF Academy, a cluster of turberculosis (TB) skin test conversions from an active case of TB at a European base, a foodborne illness during Operation Desert Shield/ Storm, a cluster of possible occupationally related respiratory diseases in a joint allied/ USAF work site, and streptococcal disease among USAF basic recruits. The ability of the AL Epidemiology Services Branch to provide rapid professional assistance in investigating and controlling outbreaks makes it an effective preventive medicine tool and contributes to the maintenance of a mission capable force.

OPR: AL/AOES, (210) 536-3471 [DSN 240]

Ranch Hand II



Ranch Hand II investigation continues to probe the effects of dioxin used in Vietnam.

At the direction of the White House, the USAF is conducting a 20-year epidemiologic investigation of possible adverse health effects of USAF personnel involved with aerial spraying of herbicides in Vietnam from 1962 to 1971 (Operation Ranch Hand). This investigation is to determine whether long-term health effects exist due to occupational exposure to herbicides and associated dioxins. In 1982, 1985, 1987, and 1992, physical examinations were given and health questionnaires administered to approximately 2,300 study participants, including 1,000 exposed persons and 1,300 in the control group. Medical histories of spouses and offspring are also tracked. Analyses of these data were published in a series of morbidity and mortality reports. A morbidity report released in 1991 using individual serum dioxin levels as a measure of exposure revealed associations between dioxin level and HDL cholesterol, diabetes, fasting glucose, and percent body fat, suggesting effects on lipid metabolism. However, any conclusion regarding cause and effect must wait for additional data analysis from physical examinations and other corroborating studies.

A major milestone in the study, the reproductive outcome report, was completed and released in the Fall of 1992. This report examined 5,489 pregnancies and 4,514 children and found no evidence to support a hypothesis of adverse effects of paternal dioxin on reproductive outcome. Another significant milestone was reached with a further refinement of dioxin half-life. This analysis indicated that the half-life varies with changes in body weight and disease. The current estimate of half-life is approximately 13 years. We are currently in our fourth cycle of examinations. We expect to examine and report on 2,300 participants.

This program has provided information necessary for executive and congressional policy decisions regarding compensation and regulation of occupational exposures. Further, procedures to investigate issues of occupational exposures and health were established. The Air Force Health Study design is becoming the worldwide statistical and epidemiologic standard for occupational disease research.

OPR: AL/AO, (210) 536-2600
HSC/YAW, (210) 536-2274
[DSN 240]

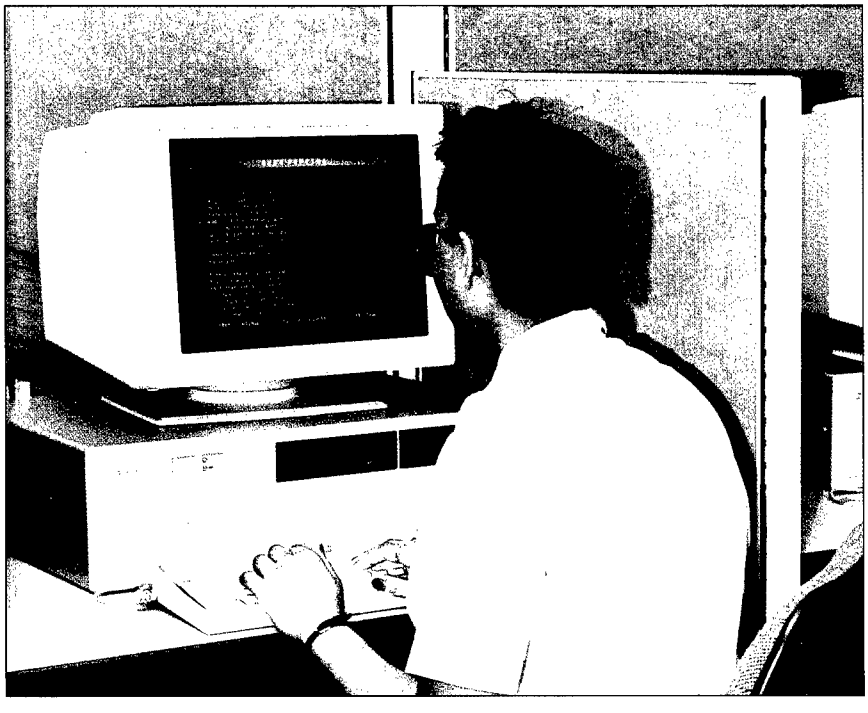
Aerospace Medicine Training Systems Analysis

The USAF School of Aerospace Medicine (USAFSAM) is currently responsible for training over 5,000 aerospace medicine professionals and technicians each year. Improvements to the present training systems are being planned in the areas of program management, engineering, and logistics support planning courseware. The USAFSAM Learning Center is upgrading hardware and authoring software capabilities on a limited scope level at this time.

The Aerospace Medicine Training Systems Analysis is being conducted to determine basic systems requirements and perform pre-acquisition planning to upgrade the present USAFSAM training systems. An assessment of the offered courses and evaluation of the training media will be conducted to ensure maximum cost effectiveness of the training methods and technologies employed.

The study will be performed as a two-phase one-year project to produce five primary products: (1) the definition of USAFSAM computer based training systems requirements; (2) a training media analysis; (3) a tradeoff analysis of existing and developing training technologies; (4) a systems specification; and (5) a long-range roadmap for future systems enhancements and direction.

OPR: HSC/XRS, (210) 536-2424
[DSN 240]



Student trains in USAFSAM Learning Center.

Operational Applications of Aerospace Medicine

The USAF School of Aerospace Medicine (USAFSAM) conducts education programs in aerospace medicine and closely related fields for officer and enlisted personnel who are in direct support of the USAF flying and missile missions. In addition to USAF members, selected students from other branches of the armed services, civilian agencies, and numerous allied countries attend courses offered at the school. Education programs are specifically designed for physicians, nurses, military public health officers, bioenvironmental engineers, aerospace physiologists, and other medical service personnel. This aeromedical education program provides quality training to over 5,000 persons each year. Courses offered range from the residency in aerospace medicine education programs for physicians to specialty training courses for airmen entering active duty. The residency is fully accredited by the Accreditation Council for Graduate Medical Education. Most of the enlisted specialty courses are accredited through affiliation with the Community College of the Air Force.

A standard course validation process fielded to the major commands (MAJCOMS) ensures the identification, documentation, and validation of the educational needs of aeromedical operations. An Education and Training Review Board validates MAJCOM training proposals which are incorporated into the training program. Courses are added, changed, or deleted based on operational need.

Computer based training is used extensively in the enlisted Air Force specialty awarding courses and is expanding in use in the professional level courses. Future plans call for the installation of a Local Area Network (LAN) which will greatly increase the students' access to large amounts of on-line information worldwide. Computer based training and the integration of high-tech educational methodologies are very much a part of the future at the USAF School of Aerospace Medicine.

A new course for flight surgeons, Aerospace Physiologists and Clinical Psychologists, was implemented in spring 1993. The Aircraft Mishap Investigation and Prevention Course is intended to prepare attendees to perform actual mishap investigations. Topics covered include aviation physiology, aviation psychology, aviation pathology, forensic pathology

Bioenvironmental engineers sampling a drum before a hazardous waste sample is obtained.

and dentistry, crash survivability, life support equipment, crash dynamics, and engineering factors in aircraft mishaps. The major emphasis of the course is on mishap investigation techniques. A new mishap lab is under construction where students will get experience in searching for evidence in a wreckage and interviewing witnesses. They will then reconstruct the accident, decide upon causes, and make recommendations to prevent further mishaps. Plans are to present the course three times per year.

The Residency in Aerospace Medicine (RAM) Program was expanded from two to three years beginning with the June 1992 class. The third year emphasizes clinical medicine topics considered key to a base level aerospace medicine program and includes rotations in occupational medicine, preventive medicine, and clinical medicine.

With the increased awareness on the importance of restoring and preserving the environment, the USAFSAM will soon expand its role in providing this vital education. Plans are underway to establish an Air Force Environmental Safety and Occupational Health (ESOH) Education and Training Integration Office within the USAFSAM. The prime role of this office will be to ensure that all USAF personnel, military or civilian, are adequately trained to carry out their ESOH responsibilities. This includes identifying disciplines and occupations requiring this education and training, the degree and level of knowledge needed, sources for the training, and monitoring the program for the entire USAF.

Through the years, USAFSAM's output of graduates and course offerings have continually expanded. Added to this is the increased complexity of the curricula. Consequently, the USAFSAM has outgrown its school facility. A new 83,500 square foot $8.9 million academic complex has been approved for construction, with completion planned for Winter 1996.

The unique blend of education, research and development, and operational aeromedical support in the aeromedical education curriculum produces qualified operationally effective aeromedical specialists for the using commands.

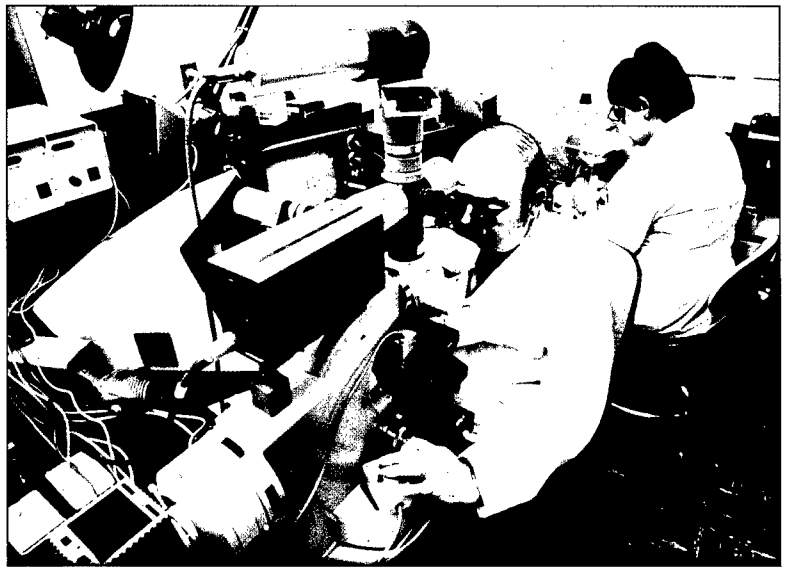
OPR: USAF School of Aerospace Medicine
(210) 536-3500 [DSN 240]

This simulation mishap acts as a training aid for a "hands-on" approach in investigative techniques.

Occupational and Environmental Health

This Human Systems Center product area assesses risks to personnel from hazardous materials, noise, electromagnetic radiation, and occupational processes in USAF operations. The work combines human-centered research and development in these emphasis areas with broad field consultation responsibilities to measure and reduce occupational illness and environmental hazards.

Asbestos Health Hazard Assessment



Asbestos fiber counting by Phase Contrast Microscopy.

It is USAF policy to remove all asbestos from the work and living areas of USAF personnel. This policy has a single purpose: prevent inhalation of unhealthy levels of airborne asbestos fibers. Base officials must follow Environmental Protection Agency (EPA) regulations for identifying and removing harmful asbestos from existing buildings. The Bioenvironmental Engineers must follow Occupational Safety and Health Administration (OSHA) requirements for monitoring occupant exposures to airborne asbestos fibers. Scientists from Armstrong Laboratory's (AL) Occupational and Environmental Health Directorate provide operational support to ensure base officials meet their requirements.

AL can analyze 6,000-8,000 asbestos samples per year. Bulk asbestos samples are analyzed by polarized light microscopy, and airborne asbestos samples are analyzed by phase contrast microscopy. Both procedures are mandated by federal law. AL also has the capability of special procedures on the scanning electron microscope. These procedures may be discussed with the laboratory. AL maintains asbestos certification with the American Industrial Hygiene Association and participates in the Proficiency Asbestos Analytical Testing Program of the National Institute of Occupational Safety and Health.

The AL provides USAF installations with information that is timely and accurate. Turnaround times are 5 to 7 days for routine samples and only hours for priority samples once received in the laboratory.

OPR: AL/OEA, (210) 536-3626 [DSN 240]

Safe Drinking Water Act Implementation

The Environmental Protection Agency's (EPA) Safe Drinking Water Act (SDWA) requires DOD to monitor, report, and notify the public of chemical contaminants in installation drinking water. It is USAF policy to provide high quality drinking water at all USAF installations. Scientists from Armstrong Laboratory (AL) provide operational support to achieve these high standards.

In 1991, AL completed a three-year effort of analysis of Phase I volatile organics as directed by the 1986 amendments to the SDWA. Scientists analyzed drinking water for 59 volatile organic contaminants from 3,600 samples from 900 USAF installations worldwide. Several bases had volatile organic chemicals in wells exceeding maximum allowable levels for which corrective action was required.

In 1992, a monitoring program of lead and copper was started for USAF installations, in compliance with the SDWA amendments. Phase II and Phase V monitoring started in January 1993. Armstrong Laboratory is preparing for rigorous quality assurance. Analysis will include volatile organics, not included in Phase I, metals, nitrate/nitrite, asbestos, pesticides/herbicides/polychlorinated bi-phenyls, and water treatment chemicals. This massive new program will cover USAF installations worldwide.

Preparing drinking water samples for metal analysis to comply with Safe Drinking Water Act requirements.

The USAF is meeting today's water monitoring requirements and is prepared for future requirements. The AL sampling analysis team will meet these challenges to ensure USAF personnel and families are provided with high quality drinking water.

OPR: AL/OEA,
(210) 536-3626
[DSN 240]

Indoor Air Quality

The Armstrong Laboratory (AL) has operated a program to investigate the causes and effects of poor Indoor Air Quality (IAQ) for the past seven years. IAQ is a term applied primarily to office space where occupants complain of health problems which disappear when they are not at work. The primary effects of poor IAQ are reduced productivity and low morale. Typical symptoms are drowsiness; inability to concentrate; dry itchy skin; irritated eyes, nose, and throat; excessive colds and allergies; and dissatisfaction with temperature or humidity.

The IAQ Program objective is to reduce illness and absenteeism among office workers and increase their productivity. AL prepares educational materials and briefings, interacts with federal agencies and national organizations, and conducts IAQ surveys at USAF bases across the continental US in an effort to prevent and remediate IAQ health problems. A key educational reference completed this year is a comprehensive "Guide for Indoor Air Quality Surveys" sent to all Bioenvironmental Engineering and Military Public Health offices. Together, with the AL Environics Directorate, we are developing guidance for base level civil engineering on the relationship of ventilation systems to IAQ. Survey customers include active duty personnel from USAF bases, the Air National Guard, the Air Force Reserve, the Defense Logistics Agency, the Army Corps of Engineers, and health professionals from the Army, Navy, Environmental Protection Agency, and Occupational, Safety and Health Administration.

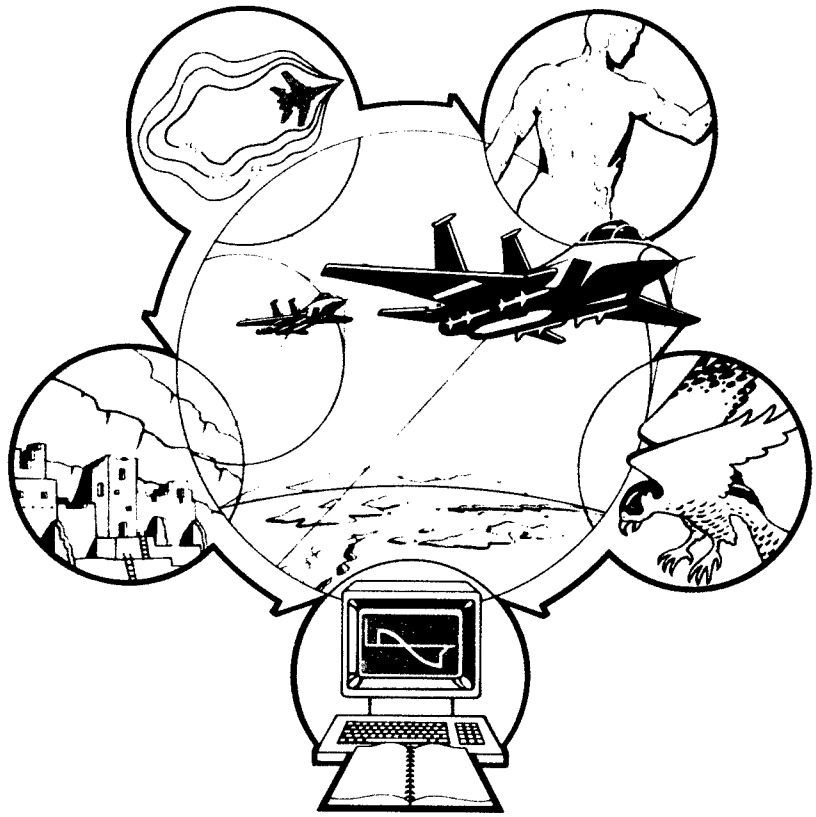
In 70 percent of the over 50 buildings investigated, a major cause of poor IAQ has been inadequate design or maintenance of the heating, ventilation, and air-conditioning (HVAC) system. Other major contributors of IAQ problems are insufficient amounts of fresh air and relative humidities below 40 percent. The IAQ program emphasizes increased awareness among both civil engineering and medical specialties concerning what causes IAQ problems, our continuing support of customer requested surveys, and giving health oriented input into the HVAC design and maintenance process within DOD.

Inspecting the HVAC system for causes of indoor air quality problems.

OPR: AL/OEM, (210) 536-3214 [DSN 240]

Environmental Noise Technology Program

Noise related problems associated with air operations are increasing as the USAF requires more low-altitude/high-power flights to maintain pilot proficiency and increase aircrew survivability. Encroachment continues as communities develop near airbase installations. Base closures and force realignment exercises intensify these problems by increasing the number of aircraft (and their noise) at the remaining bases. Each change to the operations at any USAF base, range, route or Military Operating Area (MOA) requires the USAF to evaluate the environmental impacts as defined in the National Environmental Policy Act (NEPA). The USAF must accomplish comprehensive environmental noise-impact analyses to continue operations within regulatory requirements and defend itself against litigation. The Environmental Noise Technology (NOISETECH) program develops the measurement methods, metrics, databases, models, and criteria essential in defining noise exposure and assessing its effects on humans, animals, and structures.



Technological advances in aerospace systems require noise exposure assessments.

Beta testing was accomplished for the NOISETECH computer based Assessment System for Aircraft Noise (ASAN), a planning and decision support system for predicting and analyzing the effects of subsonic noise and sonic booms on humans, animals, and structures. It will be used by the USAF operational and environmental planning communities to plan operational changes and assess the predicted environmental noise impacts of these new and modified operations. When fully implemented at the major commands, ASAN will develop legally defensible documents that describe and assess the impact of subsonic and supersonic aircraft operations on wild and domestic animals. It also assesses potential damage to conventional and unconventional structures, determines likelihood of snow avalanches or landslides, and predicts individual and community annoyance responses, sleep disturbance, and potential long-term human health effects.

New modeling capability was added to the NOISEMAP computer program to evaluate terrain effects on noise propagation near the start of aircraft takeoff roll. NOISEMAP forms the cornerstone of the DOD Air Installation Compatible Use Zone program and must be continually updated to reflect the current technology to provide legally defensible airbase noise assessments. These assessments are used to defend the airbase mission from encroachment of developing local communities. New computer controllable units have been commercially developed and integrated into our NOISECHECK II program for use in spot check monitoring that is often required in cases of controversy or litigation. An initial prototype of a noise monitoring network similar to those used in major civil airports was developed using this NOISECHECK capability. It may become necessary for military installations and controversial special use airspace to use these noise monitoring networks to obtain the degree of public acceptance necessary to avoid further operational restraints.

NOISETECH research programs involve laboratory and field studies on the effects of subsonic aircraft noise and sonic booms on both domestic animals and wildlife, including fowl, horses, caribou, bighorn sheep, the desert tortoise, and other species. Specific projects currently underway include development of a domestic animal effects model, a predator-prey interaction model, and a grazing animal model. Draft USAF position papers and assessment models for these efforts will be incorporated into ASAN.

OPR: AL/OEB, (513) 255-3605 [DSN 785]

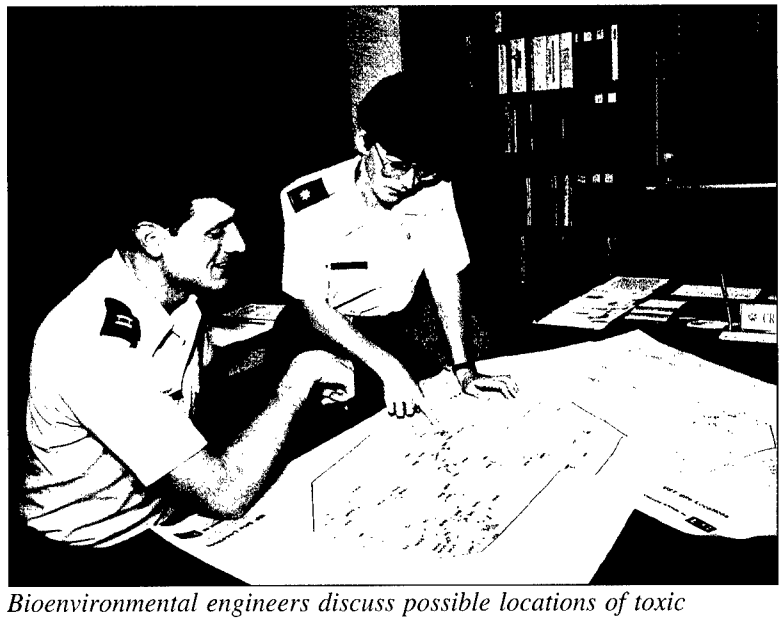
Health Risk Assessment Program

The Superfund legislation in 1980 created the Agency for Toxic Substances and Disease Registry (ATSDR) as part of the Public Health Service in the US Department of Health and Human Services. ATSDR conducts a Public Health Assessment for every site on the National Priorities List (NPL), also known as the Superfund list. The USAF in 1992 had 33 installations on the NPL for a Public Health Assessment to be performed. ATSDR reviews available information about hazardous substances at a site and evaluates whether exposure to them might cause any harm to people in the past, present, or future.

The Occupational and Environmental Health Directorate of Armstrong Laboratory (AL/OE) initiated the Health Risk Assessment Program to provide the USAF, major commands, and installations a technical center of expertise to assist with ATSDR in the health assessment process. The team of professionals consists of physicians, epidemiologists, toxicologists, bioenvironmental engineers, public health officers, industrial hygienists, and biologists. Members of the team travel to USAF bases on the NPL before the assessment process to preview the hazardous sites and identify where additional environmental data should be collected. During this process, recommendations are made to prevent or reduce personal exposure to hazardous substances. An AL/OE representative then accompanies the ATSDR health assessor during the site visit and assessment. This working association with ATSDR allows for the best flow of information providing a more complete and accurate Public Health Assessment document. This document is then reviewed by the technical experts at AL/OE for validity and accuracy in such areas as toxicology, epidemiology, biological pathways, and health impact to the person.

The AL/OE focal point acts as a liaison with the ATSDR Division of Health Assessment and Consultation. This provides for consistency of the reviews, uniformity to the health assessment process, and technical support to the installations and MAJCOMs. Since the Health Risk Assessment Program is active in the Army and Navy, AL/OE works closely with the sister services to enhance the combined capabilities of toxicology and epidemiology. The USAF has taken the lead for cleaning up the environment in and around our sites, and through this program AL/OE is working to ensure the environment is safe for the public now and into the future.

OPR: AL/OEM, (210) 536-2063 [DSN 240]



Bioenvironmental engineers discuss possible locations of toxic substances.

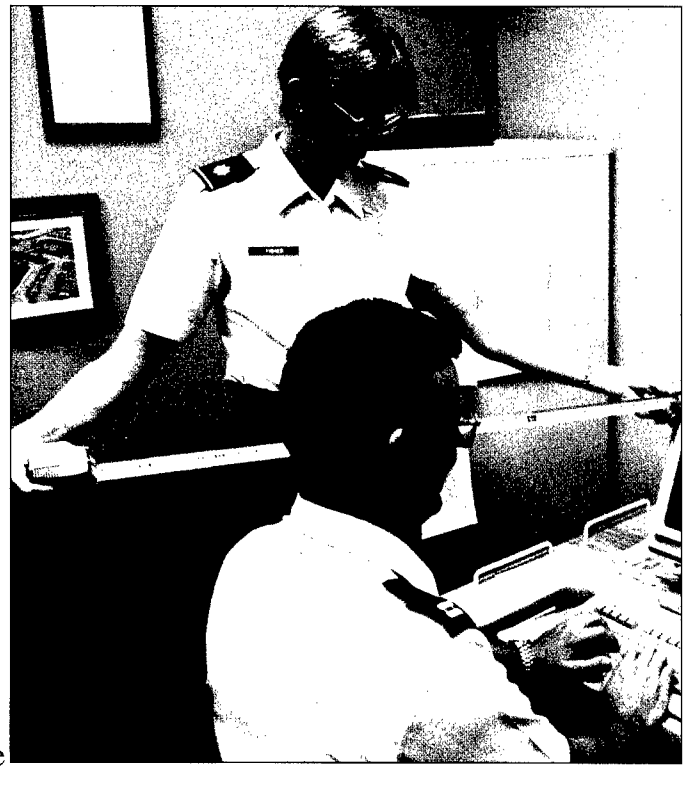
Air Force Ergonomics

Ergonomics related illness has been called the "occupational disease of the 1990's." Impairments of the muscles, tendons, nerves, and joints which occur over time in the workplace are very common; the average employee loses nearly two days of work each year due to disorders of this nature, and "cumulative trauma disorders" now comprise nearly 60 percent of all occupational illnesses reported to the Bureau of Labor Statistics. Ergonomics or the study of the "laws" of work, focuses on selectively adapting the job environment to individual needs. By achieving a close fit between workers and their environment through task, tool, or workstation redesign, the ergonomist hopes to reduce or eliminate many of the common job stressors associated with occupational disease.

In 1990, Armstrong Laboratory initiated the Air Force Center for Ergonomics Consultative Services and Information Exchange. In response to this tasking, a multidisciplinary team, composed of an occupational medicine physician, industrial hygienist, and military public health officer, was established to provide telephone and on-site ergonomics consultations to customers. Since its inception, the team has published ergonomics related technical reports and consultative letters, and conducted ergonomic surveys in a variety of work areas. High levels of cumulative-trauma illness have been identified in USAF sheet metal shops, supply, commissary, and tire shops. Most recently, the team analyzed jobs in a base parachute shop, and made recommendations for administrative and engineering design changes to minimize the ergonomic hazards found in the drag parachute packing areas.

This year, the focus has been on developing the "total program requirements" for implementing a USAF-wide ergonomics program. The Air Force Occupational Safety and Health or AFOSH standard resulting from this endeavor should ultimately have a significant, positive impact on the USAF working environment.

OPR: AL/OEM, (210) 536-2063
[DSN 240]



Measuring the computer station to ensure worker "fit."

Hazardous Waste Analysis Program

The Resource Conservation and Recovery Act (RCRA) mandates that all USAF installations conform to certain requirements to have their waste characterized and disposed of properly. In response to this need, Armstrong Laboratory maintains waste management teams to provide waste management guidance and sampling assistance.

The Human Systems Center also acts as a focal point to provide bases worldwide with an avenue to have potential hazardous waste samples analyzed. Utilizing major command Civil Engineering funds, samples are analyzed by civilian contract laboratories that are the best in the industry. Data provided by these laboratories are forwarded to Armstrong Laboratory for assessment and evaluation by highly trained scientists prior to release to the installation, thus assuring a quality product delivered to our customers.

Complete characterization of a waste is extremely expensive and time consuming. Costs can range from $700 to $2,000 per sample, and analysis can take up to three weeks to perform. Over 45 separate analyses are performed on each sample to determine if they fall into the category of hazardous waste as defined in RCRA.

All USAF installations must abide by RCRA. The hazardous waste analysis program is a key in providing bases with the information necessary to dispose of waste safely and economically while avoiding potential costly fines imposed by the Environmental Protection Agency.

Samples are analyzed to identify potential hazardous waste.

OPR: AL/OEA, (210) 536-3626 [DSN 240]

Environmental Sampling

Recent changes to the Water Quality Act, the Clean Air Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act require detailed sampling or computer modeling of air, drinking water, and wastewater. The Water Quality Act, also known as the Clean Water Act, requires permits and discharge limitations for industrial waste, sanitary waste, and storm water. The Clean Air Act Amendments require detailed emission inventories of all sources of air pollution and also contain provisions for air emissions permits. The Resource Conservation and Recovery Act rules govern the identification and disposal of hazardous waste material. The Safe Drinking Water Act requires monitoring and treatment when necessary for over 100 contaminants in drinking water.

Sampling for lead testing in a child development center.

Armstrong Laboratory (AL) environmental scientists provide technical expertise survey teams that will travel to bases and perform environmental samplings and unique in-house analysis. Bases experiencing environmental problems can contact a variety of specialized consultants for interpretation of regulations or problem-solving suggestions. On-site environmental surveys are scheduled in a priority fashion based on the urgency of the request, but can take place in a matter of days if necessary.

Most samples collected during on-site surveys are analyzed without cost to the base. The primary source of analytical support is the AL Analytical Services Division. An increasing number of permits require special analysis of samples using fish or minnows. AL can help bases avoid sampling for some air emissions by maintaining the necessary software to perform Environmental Protection Agency approved modeling of air pollution sources.

Environmental sampling teams provide a significant resource to bases in their efforts to comply with today's complex array of environmental regulations. DOD customers include civil engineers and medical personnel in all major commands.

OPR: AL/OEB, (210) 536-3305 [DSN 240]

Lead Based Paint

Armstrong Laboratory (AL) consultants are evaluating military family housing units, child care centers, and youth centers for the presence of lead based paint (LBP). According to the Center for Disease Control, lead poisoning is one of the most common pediatric health problems in the United States today. Potential sources of lead in the environment are lead based paint, industrial emissions, lead in pipes, and lead in food containers. The pathways by which lead from these sources finds its way into the human body include inhalation of air, ingestion of food and drinking water, and ingestion of nonfood solids such as paint, house dust, and soil dust. LBP is the most widespread source of lead exposure to children.

In a typical survey, bioenvironmental engineers and technicians prioritize housing units based on whether children under seven years of age or pregnant woman are presently living in the house, the condition of the paint, and the age of the unit. Units built before 1970 (especially those built before 1950) are more likely to contain LBP. The survey team uses an X-ray fluorescence spectrum analyzer to measure the amount of lead in paint. In addition, the team collects dust samples in each unit and soil samples outdoors. LBP is often found on house components such as door frames, window frames, wooden trims, and exterior walls. Levels of lead dust and lead in soil are generally within the acceptable levels established by the Environmental Protection Agency and the Department of Housing and Urban Development.

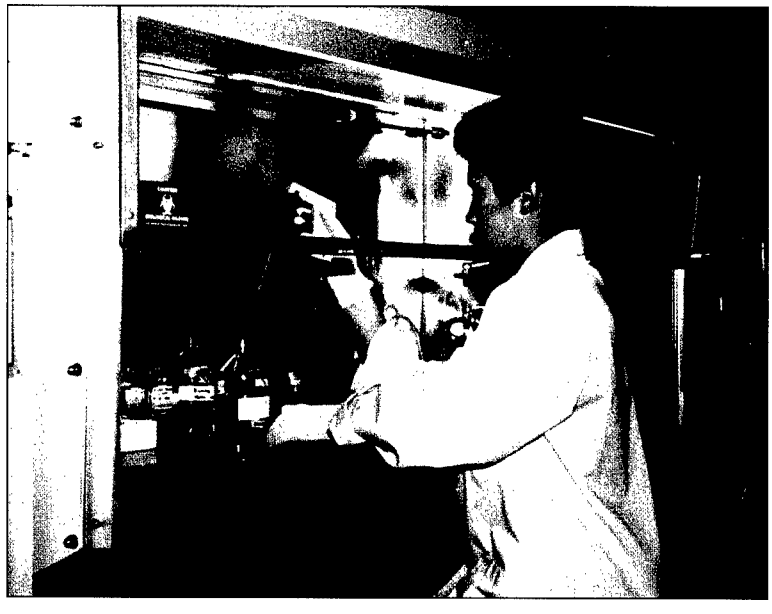
AL is now developing USAF technical guidance on LBP investigations and is a member of the DOD Interagency Committee on Lead Based Paint in military housing and other buildings.

OPR: AL/OEM, (210) 536-3214
[DSN 240]

X-ray fluorescence monitoring for lead based paint.

Toxicology Research and Development

Armstrong Laboratory's toxicology research and development defines the toxic hazards associated with fuels, chemicals, and structural materials used in advanced aerospace weapon systems. A multidisciplinary scientific research team examines the mechanisms of toxicity and recommends human exposure criteria. In addition, the team develops new methodology and creates methods to relate data from animals to humans.



Technician performing toxicity assessment on fuel sample.

Toxicology research is vital to the development and acquisition of materials designed to enhance USAF operational capability. Researchers proposed USAF materials to toxicological evaluation, enabling decisionmakers to build acquisition strategies that balance the USAF mission, health risks, environmental factors, and life cycle costs. Recently, nonflammable aircraft hydraulic fluids, new fuels, and lubricants were evaluated for USAF use. This research effort is also substantially involved in a high priority effort to find safe replacement chemicals for halons currently in the USAF inventory.

This research integrates investigations of toxicity ranging from the cellular level of target organs, to whole animals or human systems. The quantitative description of the uptake, distribution, metabolism, elimination, and toxicity of USAF operational chemicals and materials involves the use of kinetic studies, analytical biochemistry, biomathematical modeling, cancer mechanism studies, and cell culture techniques.

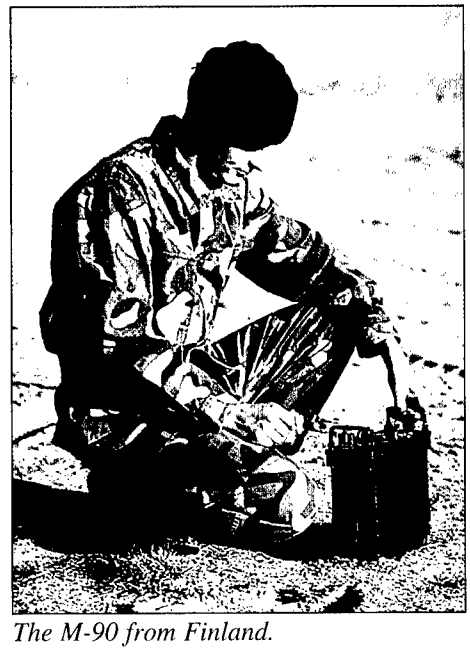
USAF toxicology research responds to a spectrum of mission driven needs ranging from rapid relative toxicity screens to long-term chronic inhalation studies. The presence of hazardous materials adds several hundred million dollars to each weapon system's life cycle and increases health risk to personnel. Ongoing research enables reducing both cost and risk to personnel health.

OPR: AL/OET, (513) 255-5740 [DSN 785]

Automatic Mustard Agent Detector

Detection and warning is a key element of preparedness for chemical warfare defensive operations. To operate effectively in a contaminated environment, commanders need to know the type and concentration of the chemical agent, location of the agent, movement and spread of the contamination, and must be alerted when the contamination has been reduced to a safe level. The automatic remotely alarmed detectors currently in use detect only nerve agents and are prone to produce false positive readings from common battlefield contaminants.

Use of mustard agents against a wartime enemy dates back to World War I. Because an increasing number of countries are developing chemical weapons, the Human Systems Program Office is pursuing a fast-track acquisition of a small number of automatic mustard agent detectors for contingency operations. The Finnish M-90 has been selected for this purchase and will be used by specialized teams to determine if the area being monitored at air bases is contaminated. It will also be used to provide a remote chemical detection capability to warn personnel of chemical attack and to monitor the atmosphere in collective protection shelters for the intrusion of contamination. Upon completion of this initial limited buy, a much larger acquisition will continue to meet the requirements for vesicant agent detection worldwide. All devices will provide timely and critical information the commander needs to improve his chemical warfare defense posture while in the battle area.



The M-90 from Finland.

OPR: HSC/YAC, (210) 536-2675 [DSN 240]

Radiation Detectors

Commanders must have a nuclear radiation detection capability to monitor nuclear materials and contamination levels during peacetime and wartime scenarios. Currently fielded USAF radiation detectors are unsupportable. This exposes military bases by providing little or no long-term detection capability. With the addition of the new radiation detector, bases will have the ability to monitor all forms of radiation for extended periods of time.

In an effort to provide a nuclear radiation detection capability, the Human Systems Program Office is conducting a commercial off-the-shelf procurement contract. The fielding of these devices will permit timely detection of nuclear radiation vital to the protection of personnel on the battlefield and in the manufacture, transportation, handling, decontamination, storage, and eventual destruction of nuclear materials. These detectors will improve operational capability in wartime and peacetime missions.

OPR: HSC/YAC, (210) 536-2675 [DSN 240]

USAF Personnel Radiation Dosimetry

USAF personnel work with various types of radioactive materials and radiation-producing machines to include nuclear medicine, radiotherapy, instrument calibration, irradiators, gauges, nuclear weapons, and research and development. The potential for exposure to ionizing radiation is present which necessitated the establishment of national standards to minimize the risk associated with exposure to ionizing radiation. The danger of ionizing radiation to USAF personnel is minimized through the proper use of personnel dosimetry.

The USAF's large-scale personnel radiation exposure monitoring program utilizes state-of-the-art software, hardware, and dosimetry to ensure the protection of the worker. Physicians, dentists, weapons inspectors and handlers, non-destructive inspection operators, and reactor operators are some of the occupations that are monitored. The system is considered to be reliable, accurate, and technically advanced.

Success of the program is essential for positive proof of compliance with Air Force Regulation 161-28 and Title 10, Code of Federal Regulations, part 20. The USAF participates in the National Voluntary Laboratory Accreditation Program (NVLAP) administered by the US Department of Commerce, National Institute of Standards and Technology, formerly the National Bureau of Standards. We have fulfilled the requirements for this certification and continue to maintain this level of proficiency in all eight categories. The Instrument and Calibration facility supports the personnel dosimetry program by providing periodic calibration of the thermoluminescent dosimeters in order to maintain a high level of quality assurance as required by NVLAP.

OPR: AL/OEB, (210) 536-3486
[DSN 240]

Reading dosimeters to determine ionizing radiation exposure of USAF personnel.

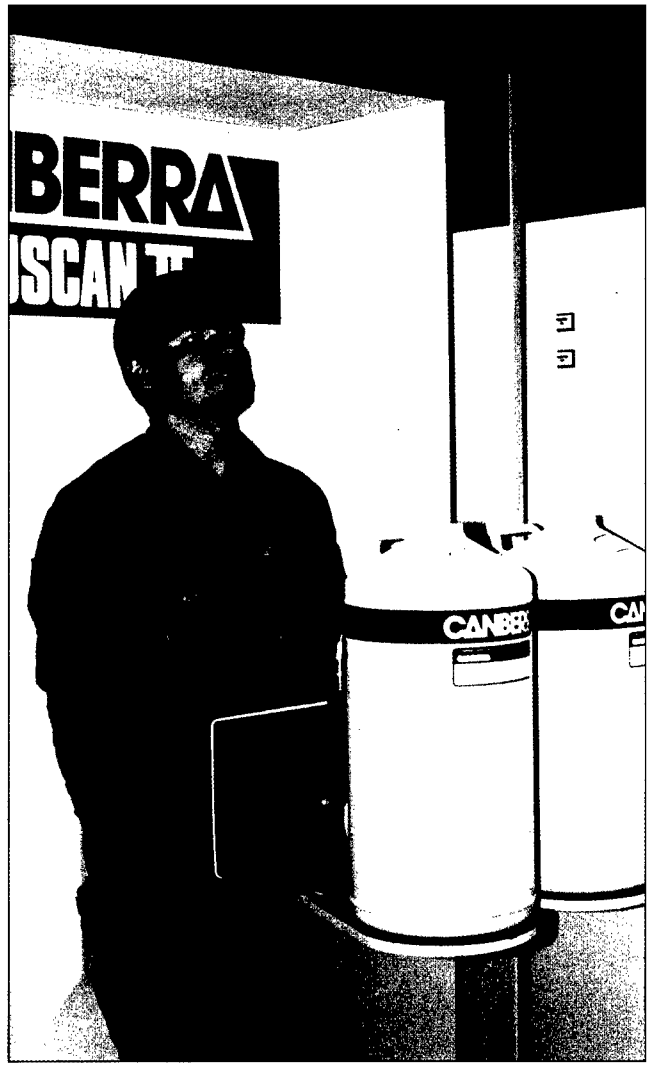
In Vivo Bioassay

Personnel who routinely use radioactive materials can inadvertently inhale or ingest these materials. To determine the amount of radioactive material internally deposited, Armstrong Laboratory utilizes a combination of instruments and procedures.

In vivo activity of gamma-emitting radionuclides is determined by using a Canberra Accuscan II Whole Body Counter (WBC). The WBC provides quantitative and qualitative determination of the radionuclide body content of potentially exposed personnel. After the ingested or inhaled activity has been determined, specialized software is used to determine the cumulative dose that is expected over the next 50 years (the committed effective dose equivalent, [CEDE]). This CEDE is then entered into the USAF Master Radiation Exposure Registry (MRER), which is maintained as a historical dose record database at Armstrong Laboratory.

Armstrong Laboratory routinely provides radioanalytical support to all the armed services in addition to the Department of Energy. This in vivo bioassay capability establishes Armstrong Laboratory as the premier radioanalytical laboratory within the DOD.

OPR: AL/OEB, (210) 536-2061 [DSN 240]



Measuring internal radiation exposure to determine short- and long-term health effects.

Environmental Bioassay

The Ecology and Bioassay Function in the Occupational and Environmental Health Directorate of Armstrong Laboratory provides aquatic and soil bioassay support for bases USAF-wide. Bioassay tests statistically compare a test organism's response to a potential contaminant versus the organism's response to an uncontaminated control. While chemical analysis can provide useful data on the make-up of contaminated water, soil, or products, only a bioassay can assess the actual hazard it may present to living things in the environment.

The Ecology and Bioassay Function uses fathead minnows (Pimephales promelas), water fleas (Ceriodaphnia dubia), algae (Selenastrum capricornutum and Photobacter phosphoreum) as test organisms for aquatic bioassays, sorghum (Sorghum bicolor), and pinto beans (Phaseolus vulgaris) for soil bioassays. Although most bioassays take several days to accomplish, the function capabilities include a computerized bioassay system called Microtox TM, which completes a bioassay in about 30 minutes.

Many bases have legal requirements for bioassays under their National Pollutant Discharge Elimination System permits. Other bioassays are requested for investigations of fish kills, lawsuits involving farming lands contaminated by fuel or oil spills, and investigations of the environmental impact of products used by the USAF, such as aircraft deicers. The Ecology and Bioassay Function complies with the Environmental Protection Agency and the most stringent state guidelines. In FY92, the function completed over 200 bioassays in support of 17 USAF installations. The Ecology and Bioassay Function provides USAF installations with a cost-effective alternative to contracting these services, some of which cost thousands of dollars per individual test and could add up to hundreds of thousands of dollars per year at a single installation.

OPR: AL/OEM, (210) 536-3214 [DSN 240]

Culturing organisms for bioassay.

Air Force Radiation Assessment Team

The Air Force Radiation Assessment Team (AFRAT), based at the Armstrong Laboratory, provides assistance worldwide for on-site detection, identification, and quantification of any ionizing radiation hazard. AFRAT stands ready in the event of a nuclear weapon accident or any incident involving the potential release of radionuclides. The AFRAT team consists of 34 extra duty personnel which includes health physicists, bioenvironmental engineers having expertise in industrial hygiene and environmental quality, bioenvironmental engineering technicians, radioanalytical laboratory technicians, a radiochemist, and an occupational health physician. AFRAT is capable of deploying to any location worldwide within 48 hours, and provides a full range of equipment and consultation to the on-scene commander in health physics, industrial hygiene, and environmental quality.

Recently, AFRAT deployed to Loring AFB ME and Keesler AFB MS. At Loring AFB, workers cutting into an abandoned and sealed weapons storage facility were potentially contaminated with radioactive material. Subsequent measurements made by AFRAT determined that the source of the contamination was naturally occurring radon gas which had accumulated in the facility due to poor ventilation. AFRAT determined that personnel involved in the initial entry of this facility were not adversely affected by the radon gas thereby avoiding widespread public concern. Follow-on AFRAT actions at Loring AFB included the development and implementation of a comprehensive health and safety plan which ensured a radiologically safe entry into the facility. At Keesler AFB, a garbage truck was turned away from the local landfill after landfill officials detected unknown radioactive material in the waste. The AFRAT succeeded in locating, identifying, and segregating the suspect material. Keesler and state environmental officials were impressed with the AFRAT's quick response and thoroughness.

AFRAT member monitoring for radionuclides during building entry operations at Loring AFB, Maine.

AFRAT provides a specialized team for radiological monitoring and assessment at any place and time. AFRAT's readiness posture is exemplified by its deployments. The interagency response community can depend upon AFRAT to set the standard for response and to retain its position as one of DOD's premier radiological accident/incident response forces.

OPR: AL/OEB, (210) 536-3486 [DSN 240]

Radon Assessment and Mitigation Program

Radon, a naturally occurring radioactive gas produced by the decay of uranium, is second only to cigarette smoking as a cause of lung cancer. The Environmental Protection Agency (EPA) estimates radon causes 5,000 to 20,000 lung cancer deaths per year in the US. Elevated concentrations of radon in homes are widespread. An EPA survey of 25 states found one in four homes tested had elevated levels. In response to this concern, Congress enacted Title III of the Toxic Substance Control Act (also called the Indoor Radon Abatement Act) in 1988, which requires testing of all federal facilities for radon. Prior to enactment of this legislation, the Armstrong Laboratory's Radon Assessment and Mitigation Program (RAMP) had already been implemented and accomplished 5,000 screening measurements at 135 USAF installations worldwide.

As a result of the screening measurements, 51 installations were targeted for year-long measurements of all residential, school, child care, and lodging structures. Of the approximately 46,000 measurements made thus far, 14 percent are above the EPA screening level. Structures identified as having radon levels exceeding the EPA level will require mitigation. In early 1993, measurements of administrative structures began at previously identified installations which are not on the base closure list. Mitigation in response to RAMP measurements is ongoing at several installations.

RAMP efforts have been proactive from the start, and RAMP continues to serve as a model for other agencies. RAMP efforts will reduce the long-term risk of lung cancer from exposure to radon for personnel living and working on USAF facilities.

OPR: AL/OEB, (210) 536-3486 [DSN 240]

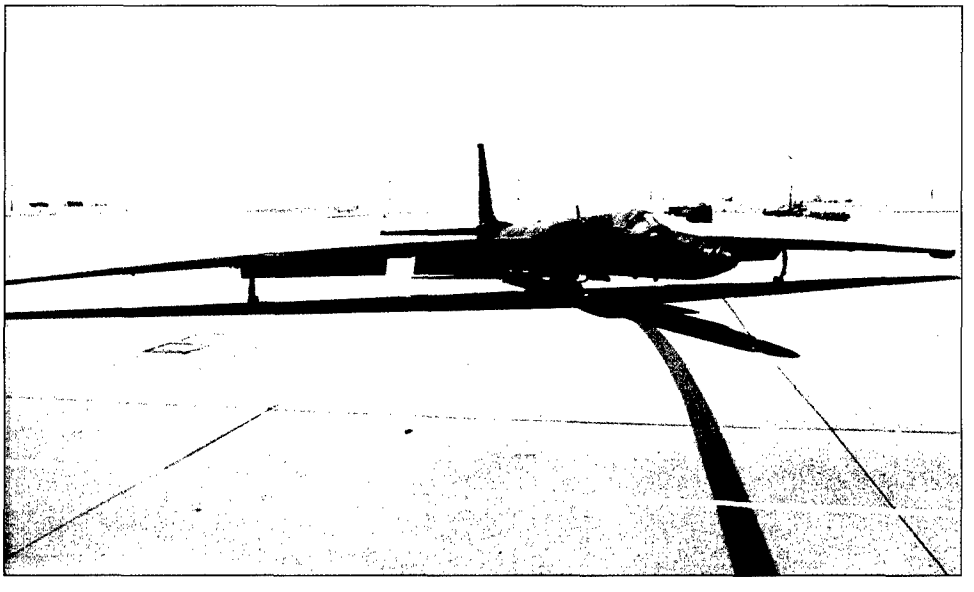
The Tech-Ops/Landauer Alpha Track "RadTrak" radon detector is a passive monitor for radon levels.

High-Flier Radiation Dosimetry Program

High altitude aircrews risk exposure to relatively high levels of naturally occurring ionizing radiation. The sources are cosmic and solar particles and their associated secondary radiations produced by interaction with the Earth's atmosphere. Under normal conditions, at high latitudes and altitudes above 40,000 feet, dose rates can reach levels on the order of rem per hour experienced during a major solar flare.

In an effort to more accurately assess the operational radiation environment and exposure to high altitude aircrews, the Air Combat Command and the Armstrong Laboratory have entered into a collaborative program to conduct radiation measurements on U-2 aircraft. Several total dose meter instruments (TDM) are under construction which will be flown routinely on U-2 missions. Detectors used will be tissue equivalent proportional counters. The TDMs will have a multichannel analyzer to register the particle spectrum. A large-scale memory will sequentially store the data and dose as a function of flight time for analysis of flight dose profiles. An LED warning feature will also alarm at a preset radiation level.

The radiation data collected will provide a database from which rapid and accurate radiation risk estimates required for military and contingency planning can be made. The dosimetry technology developed and used in this program will help decrease human health risk in these operational environments.

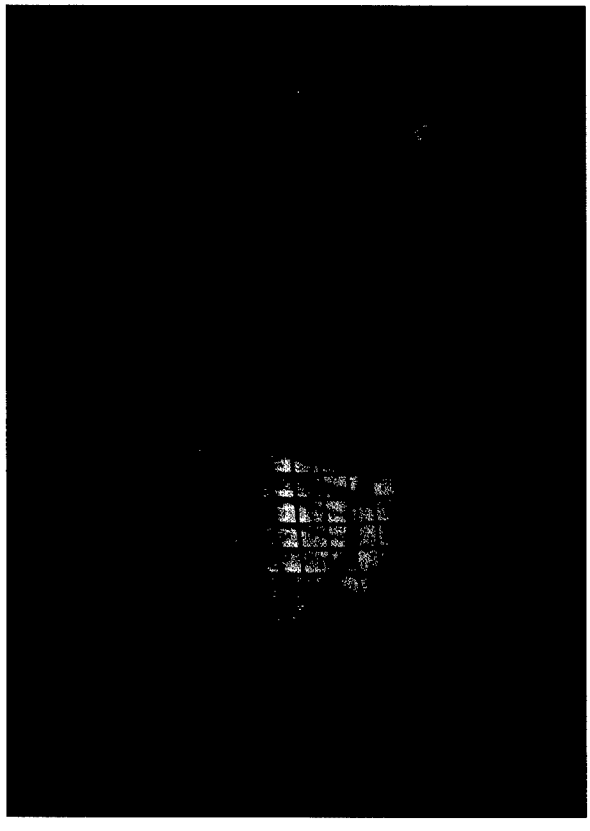


Radiation meter will measure U-2 pilot doses.

OPR: AL/OEB, (210) 536-3486 [DSN 240]

Radiofrequency Radiation Assessment

Many USAF systems produce nonionizing electromagnetic radiation. Human Systems Center researchers are improving current methods to measure radiofrequency radiation (RFR). One revolutionary approach, Thermochemiluminescent Radiofrequency Radiation Microdosimetry (TRM) uses a combination of hardware, software, and chemistry to determine the absorption patterns of RFR in models of the human body. With TRM, a plastic anthropomorphic phantom is filled with a light emitting polymer and exposed to RFR. The measured luminescence of the polymer indicates the level of absorption of the RFR signal. Because the emitted light is imaged, a map of the microdistribution of the absorbed energy is obtained in near-real time.



Human-hand phantom containing tissue simulant that luminesces.

This light emitting polymer was invented by Armstrong Laboratory (AL) researchers (US Patent 5,003,050). AL researchers have invented a biosynthetic method (patent application filed) for producing the polymer in bacteria using fermentation technology. This has made RFR dosimetry possible even in single cells. The luminescence is detected, quantified, and displayed using the USAF Quantitative Luminescence Imaging System (QLIS) on the human phantom and microscopic scale (US Patent 4,948,975). Researchers are now developing anthropomorphic phantoms capable of being placed in various postures since these geometric factors affect the amount and distribution of RFR energy absorbed.

This new technology replaces a time-consuming procedure requiring many consecutive point-by-point measurements. Critical information on RFR exposures in the workplace will be more accurate and cost-effective. In addition, this technology will result in significant new applications in civilian medical and industrial applications of RFR such as hyperthermia treatments of diseases, luminescent labeling in diagnostics, and the heat-curing of materials using radiofrequency energy.

OPR: AL/OER, (210) 536-3176 [DSN 240]

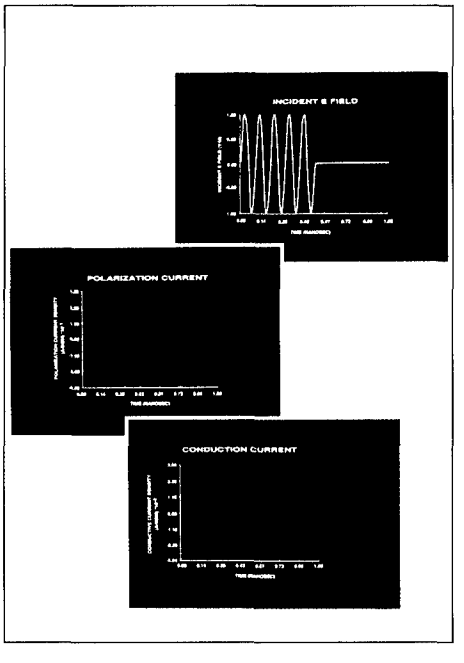
Computational Bioelectromagnetics

Ultrashort directed energy microwave and laser systems are evolving rapidly in accordance with the USAF Directed Energy Master Plan. These systems produce intense short-lived pulses of electromagnetic energy which previously have not been seen in nature. These unique and intriguing physical events represent a concern from the human health and safety point of view, and they represent an exciting and very deep opportunity to explore new classical physics' and biomedical physics' principles and applications.

In response to the health, safety, and applied science challenge and opportunity posed by the development of ultrashort pulsing devices, Armstrong Laboratory (AL) has instituted an electromagnetic computing and mathematical physics research program. This program studies the propagation of very high peak power microwave and laser pulses through living tissue. When these pulses enter tissue, they strongly couple to the charged chemical structures which are part of living cell membranes and to other key molecular structures such as enzymes, DNA (the genetic material), and RNA. The charged components of these biomolecular entities are mechanically driven by the propagating pulses, and the resulting movement of the charged components sets up a reactive electromagnetic field.

Research in the newly formed AL effort is proceeding toward an understanding of short pulse propagation in living tissue. In-house mathematical and physics researchers have defined the existence of large electric field transients produced in living tissue by impinging short pulses. In the past year, electric currents induced in tissue by electric field transients have been computed for the first time ever in the history of electromagnetic research. These currents are of two types: a conduction current that corresponds to the translational movement of free ions in the tissue material and a polarization current that corresponds to the perturbation of charges that are bound to membrane, enzyme, or other biomolecular structures. The figure shows the polarization and conduction currents induced by a one-volt-per-meter square wave modulated pulse striking a tissue surface (the incident signal). Note that the induced polarization current is substantial, being amperes per square meter in order of magnitude. A small portion of the total current is conductive in nature. It remains for future research to delimit the possibly differing biological effects of the two current flows.

OPR: AL/OES, (210) 536-3884 [DSN 240]



Tissue model current response to a 1 v/m incident pulsed field at a depth of 1 cm.

Delayed Radiation Effects in Aerospace Operations

Future aerospace missions such as high-flying USAF surveillance activities, National Aerospace Plane, Space Shuttle, Space Station or Lunar Base, will involve increased radiation exposures due to high altitude or high-latitude orbits as well as longer missions outside the protection of the geomagnetic fields. Increased hazards to personnel will require radiation-protection measures based on in-depth knowledge of the risks. Exposure to ionizing radiations is associated with higher probabilities of developing cancers and visual cataracts as well as lowered life expectancy. The Delayed Radiation Effects research program was designed to assess the long-term radiation risks for personnel in aerospace operations and will develop practical guidelines for crew protection.

Resolution of health risk problems associated with late effects of space radiations is best achieved by studying long-lived physiological models. Our research on radiation-induced cancer, cataracts, endometriosis, and genetic (chromosome) damage in a model system close to man will help define parameters in such areas as spacecraft and aircraft shielding design. In addition, spinoffs from the ionizing radiation research project, especially in the area of genetics, will have an impact on investigations of late effects of chemicals and other environmental toxins to which personnel may be exposed on the surface of the earth; for example, in base cleanup operations.

The 30-year space radiation biology database provides for rapid and accurate radiation risk assessments required for military decisions and contingency planning. The development and applications of dosimetry technology and evaluations of late radiobiological endpoints will help decrease short- and long-term human health risks and ensure the highest probability of mission success.

OPR: AL/OER, (210) 536-3416 [DSN 240]

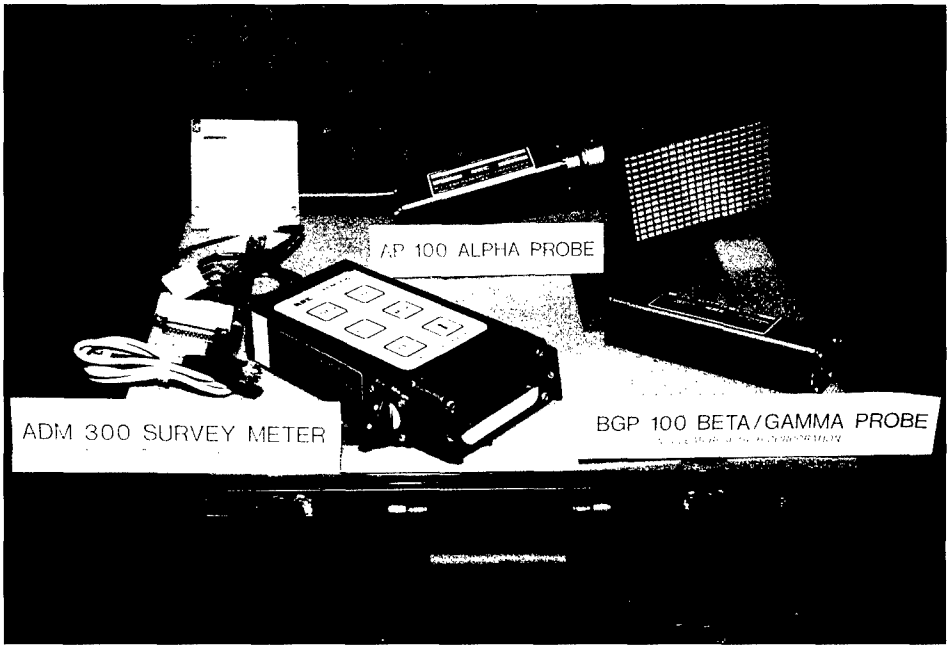
Molecular probes for human chromosomes which detect aberrations in monkey cells following irradiation with protons.

Initial Development of Roadmap for Radiological Detection: Concept Study

Despite changes in the geopolitical environment, the USAF must remain technologically current to adequately support personnel during both peacetime and wartime situations. One area in dire need of technology refreshment is radiological detection. Current radiological detection equipment is obsolete, is limited in capability, and requires excessive maintenance. This situation must be remedied to meet projected USAF requirements.

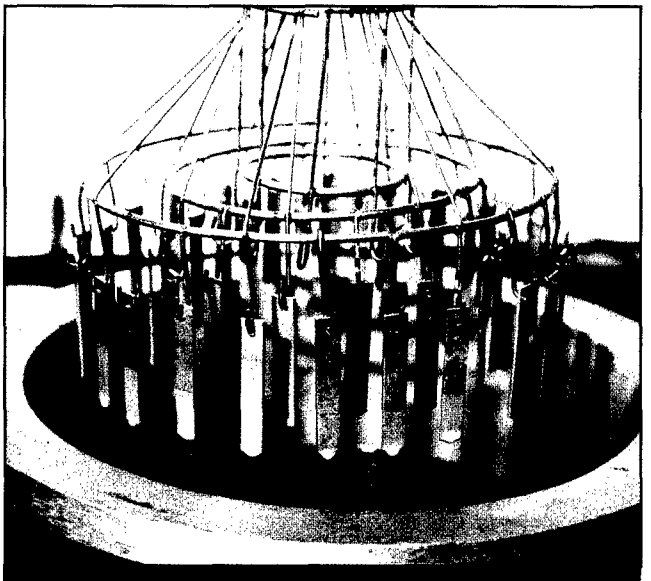
The Radiological Detection study will meet USAF requirements by determining our current capabilities and what we must do to meet our future requirements. There are four major objectives of this study. First, identify and summarize the current operational radiological detection equipment throughout DOD. Second, identify and summarize radiological detection related research and development throughout DOD. Third, develop initiative programs to eliminate technology gaps and meet USAF requirements. And fourth, develop an implementation plan (i.e., roadmap) for the initiative programs. The results of this effort will ensure the USAF can meet future demands.

OPR: HSC/XRS, (210) 536-2424 [DSN 240]



Candidate radiation detection devices are currently under review.

Environics



This Human Systems Center product area provides environmental quality technology that supports the Air Force mission by reducing the cost of cleaning up past waste sites while assuring, through compliance, the completion of critical wartime and peacetime missions. Environmental Quality efforts at Tyndall AFB, Florida, center on low cost highly effective ways to prevent environmental problems and to restore existing facilities.

Microorganisms Used in Biodegradation

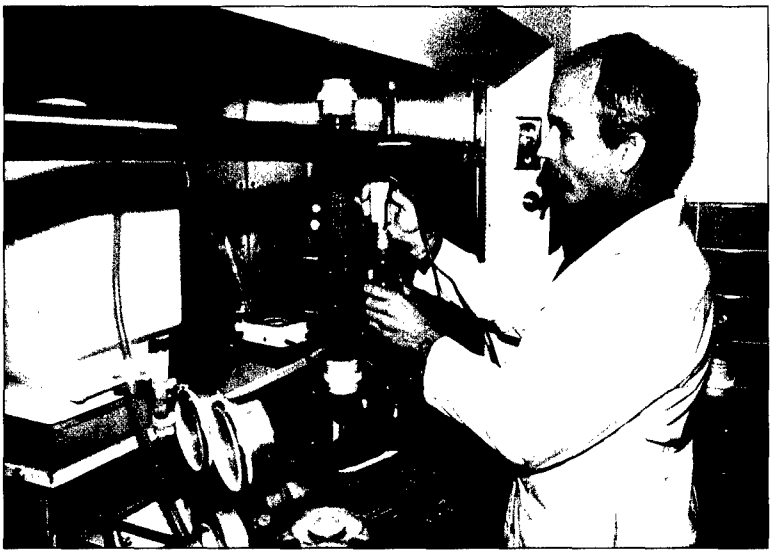
To address the need for an effective and inexpensive groundwater treatment technology, researchers at this laboratory have isolated a strain of Pseudomonas bacteria which readily destroys complex pollutant mixtures. In laboratory tests, the microorganism converts these contaminants to harmless materials such as water, carbon dioxide, and chlorides. In bench scale experiments, complex mixtures of solvents were reduced to nondetectable levels in 30 minutes.

After extensive fundamental research on the metabolic capabilities of the microorganism, scientists tested the concept in the field to determine its applicability to USAF pollution problems. A pilot plant bioreactor was tested at Kelly AFB TX, where the soil and groundwater in an abandoned waste storage area had been contaminated by various solvents and chemicals.

Preliminary tests were conducted on groundwater under a variety of operating conditions. The system reduced concentrations of benzene, toluene, chlorobenzene, and dichlorobenzene from parts-per-million level down to the parts-per-billion level when the reactor was operated at a 40-minute retention time. Results are being evaluated for use in an Installation Restoration Program feasibility study for cleanup of this site. A second field test is planned to collect additional operating data for use in the design of a full-scale system.

This technology can be used for more effective pump-and-treat remediation at any installation where groundwater has been contaminated by aromatic solvents and chemicals, and where economic cleanup and site restoration are imperative. Biodegradation offers an effective inexpensive treatment alternative to traditional physical and chemical treatment technologies. Although the technology can be widely used by the USAF and DOD, its technology transfer potential to the private sector is even greater. Knowledge gained from these studies will result in more effective pump-and-treat remediation and may lead to later use of Pseudomonas strains for biodegradation of aromatic solvent compounds on an in situ basis.

OPR: AL/EQ, (904) 283-6272 [DSN 523]



Biodegradation studies.

Bioventing for Enhanced Biodegradation

Soil bioventing is a modification of soil venting technology which is used to treat contaminated soil. Soil venting pulls air through a perforated well in the contaminated zone, using a vacuum pump system. Air can enter passively through an open well or be injected through a well. The air flow volatilizes and removes the contaminants bound to the soil and provides oxygen to the soil bacteria. Air Force Civil Engineering Support Agency (AFCESA) first conducted a small-scale test of bioventing technology at a jet fuel contamination site in a sandy permeable aquifer at Tyndall AFB FL. Goals included optimizing the amount of hydrocarbon removal by in situ biodegradation while minimizing the volatilized hydrocarbons given off in the vented airstream. The effect of adding nutrients and moisture to the subsurface to stimulate bacterial growth was also studied. Operating the bioventing system under optimum conditions resulted in 85 percent hydrocarbon removal by in situ biodegradation. A full-scale demonstration of bioventing was done at Hill AFB UT and a feasibility study is underway at Eielson AFB AL to determine the applicability of bioventing in a subarctic environment. To expand the range of sites where bioventing can be used, a large-scale test will be conducted in the northern US under less permeable conditions. Results indicate this may be a low cost, highly effective remediation technique that is transferable to the public. The Air Force Center for Environmental Excellence is transferring this technology by implementing bioventing as a cleanup technology at 50 USAF sites.

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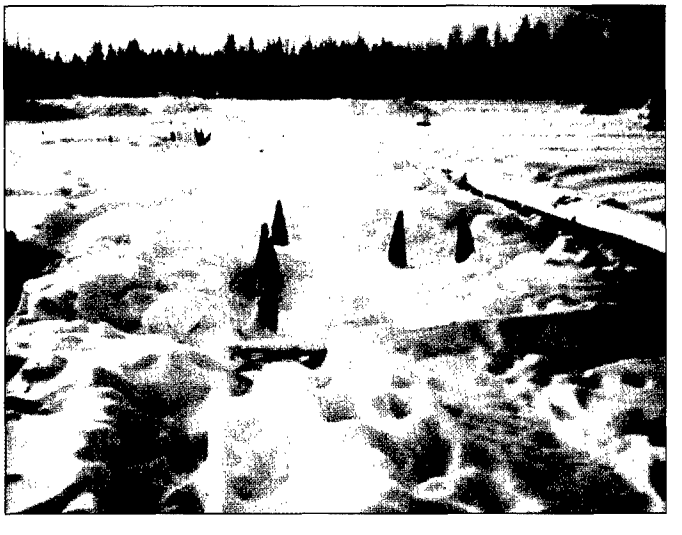

Bioventing under Arctic conditions.

Biodegradable Solvents and Cleaners

Solvents and cleaners are used at the USAF air logistics centers and base level aircraft maintenance facilities for degreasing and removing wax and paint before repairing or electroplating the parts. Most solvents are toxic and combustible. Many, such as the 1,1,1-trichloroethane used in vapor degreasing, cannot be treated with biological processing methods used in most Industrial Waste Treatment Plants (IWTP). Waste from the process must be placed in drums and shipped elsewhere for disposal. Other solvents such as chlorofluorocarbon-113 (CFC-113 or Freon-113) and perchloroethylene will soon be placed under stricter EPA control because of their potential ozone-depleting effects. The Air Force Civil Engineering Laboratory's (AFCEL) program identifies both solvents replaceable with biodegradable products and the biodegradable solvents that can be used and develops implementation procedures. Solvents were screened for biodegradability, cleaning efficiency, and corrosiveness. Of 40 solvents passing cleaning and biodegradability tests, ten passed the basic test criteria; five survived further testing. Other evaluations include economics, solvent life, process control, and whether replacement solvents create an increased organic load that adversely affects biological treatment. Testing is underway to demonstrate the solvents and processes on aircraft parts being overhauled at Oklahoma City Air Logistics Center. Results indicate that effective biodegradable solvents are available that can be treated in the IWTP system.

In addition to the Biodegradable Solvents research program, AFCEL co-sponsored the annual International Workshop on Solvent Substitution. This joint conference with the Department of Energy brings together experts from government and industry to ensure the successful transfer of solvent substitution technologies. The first two workshops took place in Phoenix, Arizona, and have been hailed as the foremost conferences on hazardous waste minimization through solvent substitution.

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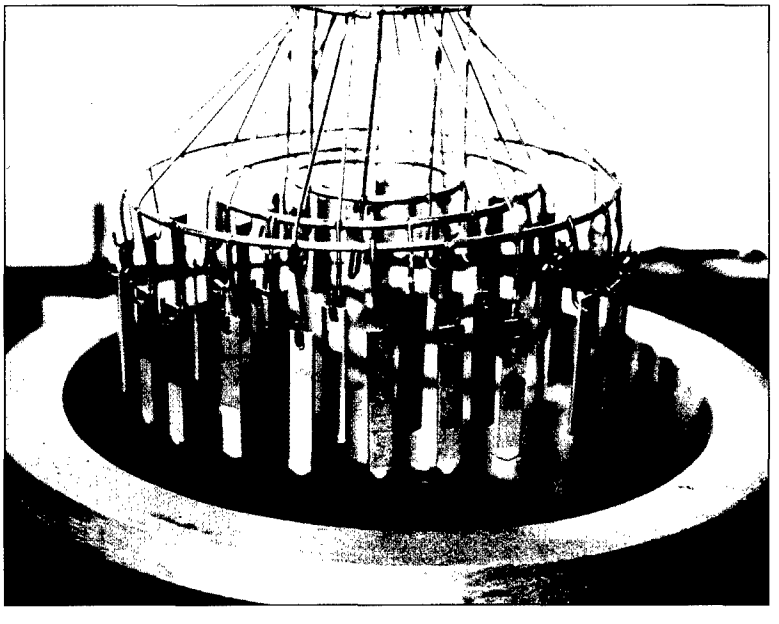

Metal tabs used to test solvent-cleaning capabilities.

Solid Rocket Propellant Disposal Program

Armstrong Laboratory is developing safe environmentally acceptable alternatives to the open burning and open detonation (OB/OD) of solid rocket propellants. The only methods currently available for disposal of ammonium perchlorate (AP)-based, solid rocket propellants are OB/OD or static firing. During these procedures, the burning propellant produces toxic corrosive hydrogen chloride (HCl) gas. This production of toxic gas and the dispersion of unburned propellant from OB/OD are environmentally unacceptable.

The program plan will develop a disposal process for the elimination of Class 1.1 and Class 1.3 propellants generated from the manufacture, maintenance, refurbishment, and disposition of Air Force missiles. The plan addresses three critical aspects of propellant disposal: removal of the propellant from the motor casing, pretreatment of the propellant for processing, and recovery and disposal.

For Class 1.3 propellants, extraction and reclamation of propellant ingredients proved the most desirable disposal method because it reclaims strategic ingredients for resale and reuse (aluminum and ammonium perchlorate).

Hot water dissolves the ammonium perchlorate from propellant components. Filtering the solution removes any entrained solids, after which the pure ammonium perchlorate crystallizes as the liquid cools. The crystals are recovered as a wet cake. Oxidizing the remaining binder material leads to the recovery of the aluminum as aluminum oxide. Waste, which contains dilute concentrations of AP, can be biodegraded and sent to the sanitary sewer or discharged. Indeed, if ammonium perchlorate recovered in this manner meets or exceeds military specification standards for virgin material, it may be reclaimed and sold.

No nonpolluting method exists to safely remove and dispose of Class 1.1 propellants [which contain mass detonating ingredients such as nitroglycerine (NG), cyclotetramethylenetetra-nitramine (HMX), and nitrocellulose]. Our proposed process removes the propellant from the motor casing and converts it into a powder. The powder is washed, separating the soluble AP and NG from the insoluble HMX, nitrocellulose, aluminum, and binder. The AP/NG solution is reduced to chloride and nitrogen gas prior to reducing the carbon content and discharging to the sanitary sewer. The insoluable mixture is oxidized to carbon dioxide, water, nitrogen, and solid salts.

A bioreactor is now demonstrating biodegradation of rocket fuels. A joint effort is planned with this laboratory and other DOD agencies cooperating to solve this problem. The program, useful both in DOD hazardous waste disposal programs and in solving applicable NASA problems, is need driven and highly transferable.

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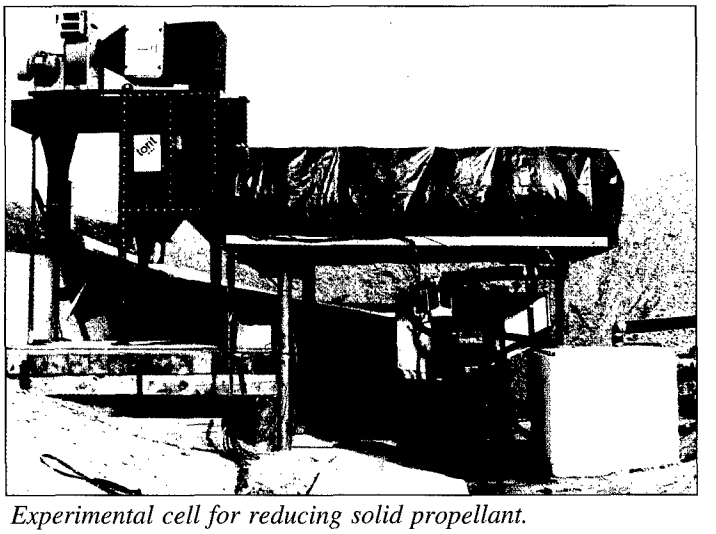


Experimental cell for reducing solid propellant.

134 Technology Transfer

To derive maximum return on our country's technology investments and enhance US competitiveness, Congress has passed legislation to encourage the transfer of federally funded or originated technology to the private sector. Most recently, the Federal Technology Transfer Act of 1986 provided significant new authority for the USAF laboratories to enter into Cooperative Research and Development Agreements (CRDA) with private companies and public nonprofit organizations, and to negotiate license agreements of intellectual property on behalf of the government.

CRDAs provide an easy way for industry and nonprofit organizations such as academia to collaborate with USAF research and development activities to facilitate technology transfer for the technological and financial benefits of both parties. The USAF benefits by:

- Improved opportunities to develop and transfer technology
- Accelerated interaction with industry to transfer basic research findings to the commercial development process
- Increased familiarity with market needs
- Sharing of royalty income with the inventors and the laboratory

The collaborating organization benefits by:

- Improved access to USAF scientists and facilities
- Better access to expertise related to research results and inventions
- Options to exclusive licenses on inventions made under the CRDA
- Profitable new products and processes

Many Armstrong Laboratory technologies have near-term potential for CRDAs or license agreements, which include many technologies contained in this book, plus additional technologies available through the Armstrong Laboratory Office of Research and Technology Applications (AL/XPTT).

OPR: AL/XPTT, (210) 536-3817 [DSN 240]

Systems Acquisition School

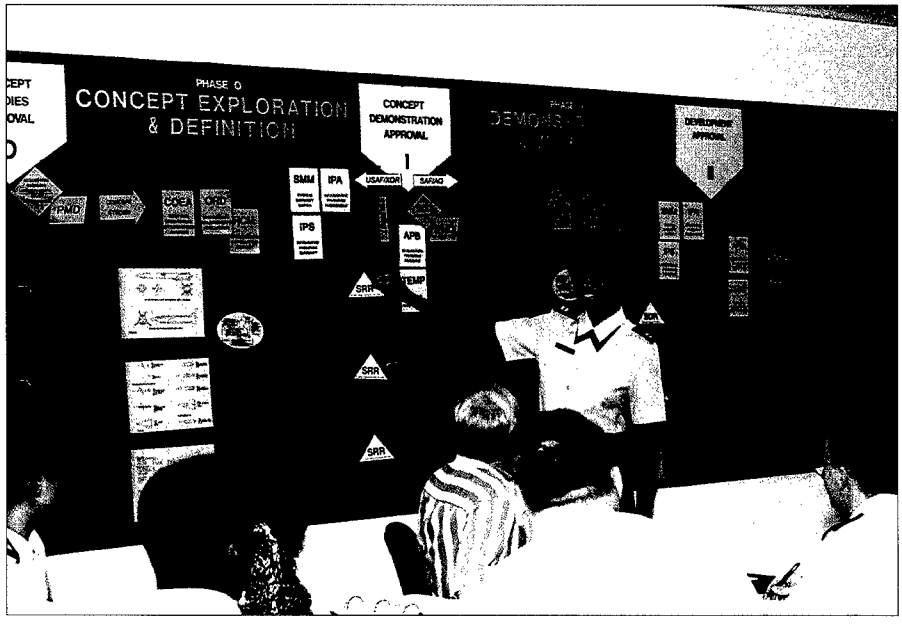
The Air Force Materiel Command (AFMC) has a legacy of being a DOD leader in acquisition techniques and processes. To instill and maintain this excellence, formal education and training is viewed as a key component. Two thrusts are currently pursued, professional accreditation training for the Acquisition Professional Development Program and command unique acquisition training for specific AFMC needs. To meet these thrusts, AFMC sponsors a command unique acquisition "school house."

The Systems Acquisition School (SAS) provides critical acquisition education and training. Most courses are one-to-two weeks long and are provided in a resident interactive format. However, to meet command needs, any SAS course may be requested for a "road show" offering. The school is "self-contained" providing curriculum development, instruction, and full registrar services. Field experts are recruited from across the command for a tour of instructor duty -- the instructors are known for being top in their respective arenas. The school relies on these experts to teach. The benefit for AFMC is a quick response, expert training resource which can provide solid acquisiton fundamentals and also adapt to the fast changing DOD and AFMC acquisition environments. The Systems Acquisition School stands ready to support command acquisition training needs.

Courses offered (subject to change) are:

Computer Resource Acquisition Course
Subcontract Program Management
Intermediate Systems Acquisition Management
Work Measurement in Pricing Applications
Laboratory Acquisition Management Course
Integrated Product Support Course
Basic Systems Acquisition Management (Medical)

OPR: 615 SCHS/CC, (210) 536-2623 [DSN 240]



Training excellence: A resident interactive session.

Studies and Analysis

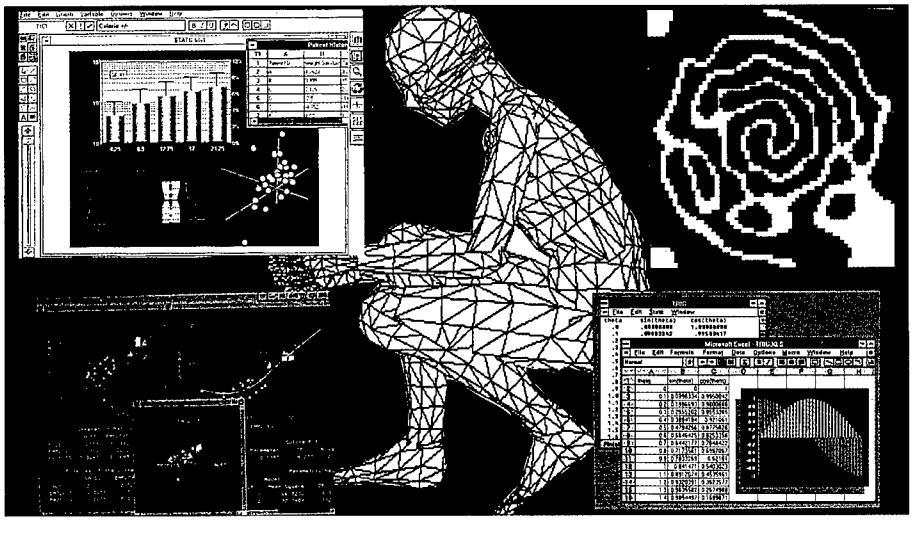
Operational requirements have historically focused more on hardware parameters than on human performance. This man-machine imbalance always produces increased costs and reduced mission effectiveness. The Human Systems Center's Studies and Analysis Division (HSC/XRS) helps users acquire human enhancing technologies that optimize mission performance. Examples of HSC/XRS services include:

- Pre-acquisition requirements analysis to identify human and environmental impacts of new/ changing defense systems, missions, threats, or deployment and support concepts
- Assess the potential of emerging human systems technologies to meet user operational requirements
- Develop/evaluate analytically derived operational systems concept options based on emerging technologies
- Provide data and decision aiding tools that help users select optimal man-machine systems requirements

HSC/XRS's modeling and simulation capability is being expanded to improve quality, scope, and responsiveness of its services. This increased capability will also support:

- Process improvement studies to enhancing a unit's ongoing internal operations
- Strategic planning studies to help focus HSC's technology base towards its customer's long range needs

OPR: HSC/XRS, (210) 536-4452 [DSN 240]



HSC's Studies and Analysis Division is often the first step towards enhanced mission performance.

Organization Functional Statements

HQ Human Systems Center

Works with customers to enhance our warfighters' competitive edge by providing superior human-centered technology, systems, education, and support. We are the systems' independent advocate for the human in design, deployment, and operation of aerospace systems.

Human Systems Program Office

Enhances USAF ground crew and aircrew survival and performance through advanced development, engineering and manufacturing development, production, and operational support of human-centered systems and equipment. This includes life support equipment, aircraft escape systems, crew station equipment, computer based training and intelligent tutor systems, nuclear/biological/chemical defense systems, aeromedical systems and equipment, AF uniforms/clothing, mishap and analyses, and environmental technologies.

Armstrong Laboratory

Plans, manages, and conducts research, advanced technology development, and specialized operational support for the readiness, maintenance, protection, and extension of human capabilities in USAF weapons systems and operations. Functional responsibilities include environmental quality, occupational and environmental health, crew-systems integration, aerospace medicine, and human resources.

USAF School of Aerospace Medicine

As the center for aerospace medicine education, the USAF School of Aerospace Medicine is the major provider of educational programs involving aviation, space, and environmental medicine for USAF, DOD, and Allied Nations personnel. The programs span entry level through graduate medical education in all disciplines encompassed in the aerospace medicine specialty.

615th Systems Acquisition School

Responsible for advancing the education of acquisition professionals in development and acquisition policies and processes, to support and sustain all USAF weapon systems.

648th Air Base Group

Operates and maintains Brooks AFB and provides base element support to Human Systems Center, three USAF Field Operating Agencies, tri-service laboratories and the USAF School of Aerospace Medicine. Support includes, but is not limited to, plans, civil engineering, communication and computer systems, transportation, supply activities, child development, recreation, base security, mission support, command post and family support programs.

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